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The Theory of Steam Turbines.—I.

By FRANK FOSTER, B.Sc.

BEFORE proceeding to consider the actions in a steam turbine at any length it will be well to make clear a few fundamental principles, and to describe very briefly the different types of turbines.

In the first place, it must not be imagined that the driving force in a turbine is the (statical) steam pressure. All turbines derive their power from changes in the motion of the working fluid (steam in this case). The pressure in a turbine might be infinite, yet unless the steam possessed the requisite velocity the turbine would not act. On the other hand, if the steam possessed the requisite velocity then the pressure might be—if that were practicable—absolutely zero, and yet the turbine would work quite normally. The statical steam pressure acts equally on the back and front of each vane, and hence produces neither end thrust nor rotation. As the steam passes through the turbine the direction of its motion is altered by the vanes, and hence these vanes must exert force on the steam. It is this force, or, rather, the corresponding reaction of the steam on the vanes, which causes the rotation and where, as in the Parsons turbine, the vanes are not symmetrical end thrust.

When steam is expanded adiabatically the amount of work which it does depends only on the initial pressure (and temperature, if superheated) and the final pressure. In the ordinary steam-engine cylinder this work is done on the piston. In a steam turbine it is done on the steam itself, and hence appears as velocity or kinetic energy. We shall have occasion later to prove this, when we come to the design of steam nozzles.

There are two classes of turbines depending on the way in which this velocity is created and absorbed by the turbine wheels.

In the first—or, as it is usually called, action class of turbines—the steam is completely expanded, and acquires its full velocity in specially formed steam nozzles. It is then passed into the turbine proper, the velocity being reduced by the vanes, and its energy reappearing as work on the turbine shaft. The De Laval, Rateau, Curtis, and Riedler-Stumpf turbines belong to this class.

In the second class—or reaction turbines, as they are called—the generation and absorption of the kinetic energy in the steam proceed simultaneously, so that the velocity of the steam is never very great compared with what it is in turbines

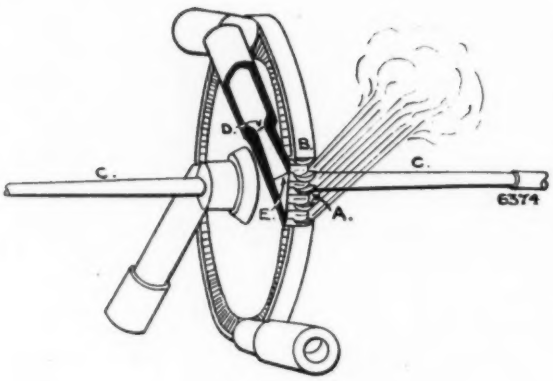


FIG. 1.

of the first class. It follows that since the velocity is being generated whilst the steam is passing through the turbine, the passages through the guide and wheel vanes must be carefully designed; each passage being in fact part of a special kind of steam nozzle. The Parsons turbine is the only practical turbine of this class.

De Laval Turbine.—Fig. 1 gives a good idea of the main features of this turbine. There is a single turbine wheel *B*, mounted on the shaft *C* and carrying on its rim the vanes or buckets *A*. Steam from the boiler is expanded in the nozzles (of which four are shown) *D*, leaving them with a velocity of from 2,500 to 4,200 ft. per second, according to the stop-valve and exhaust pressures. It then impinges on the vanes, and passes through or between them to the exhaust. The reaction of the steam on the vanes causes the wheel to rotate. The fundamental objection to this type of turbine lies in the fact that, for efficient working, the velocity of the vanes must be about half that of the steam leaving the nozzle; that is, usually, about 2,000 ft. per second. This speed is unattainable, although in the largest sizes about 1,400 ft. per second is obtained.

There are two ways of getting over this difficulty as to wheel speed whilst still retaining the general features of this class of turbine.

In the first there are several wheels, each rotating in a separate chamber, but usually on the same shaft, and having its own set of nozzles which take steam from the chamber preceding it. Each chamber with its component nozzles and wheel is in principle a complete De Laval turbine. The Rateau turbine is a good example of this class. Its nozzles differ in shape from the De Laval nozzles.

The other method consists in having a series of turbine wheels alternating with a series of guides. The steam from the nozzles (Fig. 2) passes into the first wheel, which absorbs a fraction only of its velocity; the steam then passes into the first set of guides which alter the direction but not the magnitude of the velocity, and direct it on to the vanes of the second wheel, and so on until the bulk of the kinetic energy has been extracted from the steam, each wheel taking up a portion only. If desired, the wheel speed can be further reduced by dividing the whole expansion into several stages, each stage being really a complete turbine of the type just described. This type is ably represented by the Curtis turbine, which has several stages, each stage as above described.

The Riedler-Stumpf Turbine belongs to the same general class as the preceding, but differs considerably in its construction. The vanes in this case are semicircular buckets (Fig. 3), placed on the rim of the turbine wheel somewhat like slates on the roof of a house; each bucket is partly covered by the next in order round the rim, the entrance and exit being of course quite free from obstructions. There are several modifications of these turbines. In one there are two sets of buckets side by side on the rim (Fig. 3). Steam issues at full velocity from the nozzle *A*, striking the bucket *B*. The buckets are travelling at a relatively slow velocity, so that the steam

leaves the bucket which has now travelled as far as, say, *C*, and is discharged into the guide passage *D*, which conveys it round to the other side of the rim and discharges it against the bucket *E*, which it leaves at *F*. It may now pass to exhaust or again over a similar path, depending on the velocity of wheel. The greater the number of times it traverses such a path the slower the wheel speed and also the greater the friction (steam friction) losses. In another modification of the Riedler-Stumpf turbine there is only one set of buckets on the rim. The guide *D* delivers the steam at a point further round the rim than the steam nozzle.

All the above types of turbines belong to what is called the action class of turbines, although all turbines are really reaction machines.

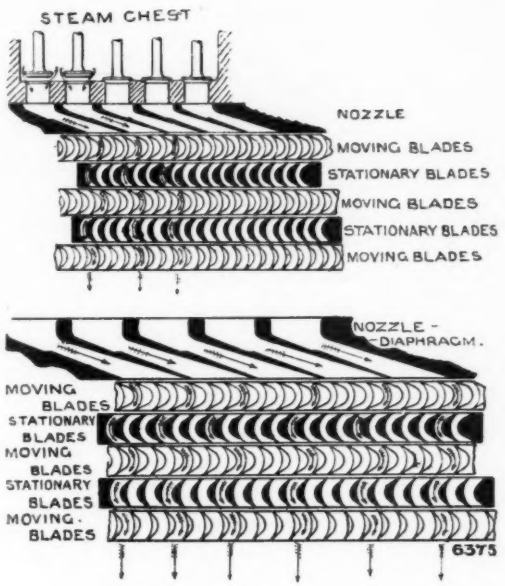


FIG. 2.

The Parsons Turbine is commonly called a reaction turbine. It differs radically from those previously described. It consists (Figs. 4 and 5) of a series of alternate fixed guides and wheels. The guides act like nozzles reducing the steam pressure, thus generating velocity and directing the steam against the next wheel. The wheel absorbs part of the kinetic energy, but at the same time the vane passages in it are so shaped as to generate fresh kinetic energy. About half the kinetic energy absorbed by each wheel is generated in that wheel, the other half in the guide. Hence as the steam passes through the turbine its velocity fluctuates a little, but is never very large, whilst the pressure falls and the volume correspondingly increases. Hence, for good results, great care is requisite in designing the forms and sizes of the guide and wheel passages. Not merely must the vanes have the correct theoretical shape, but if economy of construction is desired they should all be of the same shape. We shall see later on how to accomplish this. Fig. 4 shows a parallel-flow turbine, that is, one in which the general direction of flow of the steam is parallel to the shaft. Radial-flow turbines have been built. In them there are several stages, in each of

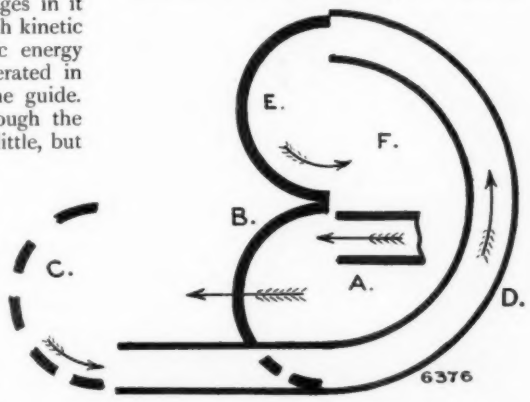


FIG. 3.

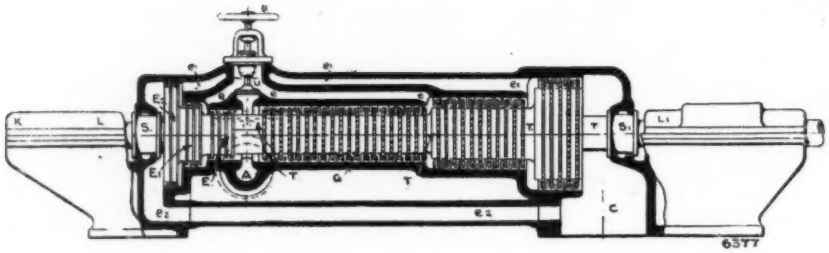


FIG. 4.

which the steam flows radially away from the shaft. The principle is the same for both radial and parallel-flow turbines.

Energy of Steam.—The energy in steam consists of pressure energy, heat energy due to its temperature and gaseous state, and velocity energy. Unless the steam does work on external bodies, the total energy remains unaltered; hence by lowering the pressure we can increase the heat or velocity energy, or both. In the turbine we want to have as much velocity energy as possible. Now, if the steam expands adiabatically it does a certain amount of work. In the ordinary steam-engine cylinder this work is done on the piston. In a steam nozzle it is spent in creating velocity in the steam. Hence we can easily calculate the velocity produced by a given drop in pressure. Unless we are very careful, however, much of this velocity will be destroyed by friction against the sides of the nozzle and internal or eddy friction. Neglecting these losses, the expansion gives rise to the same changes in temperature pressure, volume and dryness as if the expansion had taken place in a non-conducting cylinder under a loaded piston.

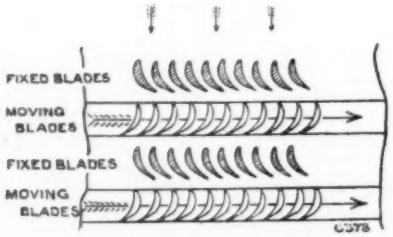


FIG. 5.

Orifices and Nozzles.—When steam issues from a vessel at a high pressure into a region of low pressure through a thin-lipped orifice, the form of the jet is somewhat as in Fig. 6. The elementary streams of steam converging towards the orifice cause a contraction in the section of the jet just outside the orifice. A similar action occurs when using a tube nozzle. The contraction of section will still occur, and hence with a sharp-edged inlet the tube at the contracted section will be partly filled with eddies (shown black, Fig. 6). Hence the inlet should be rounded a little.

The pressure at the contracted section is not that of the receiving space, unless this pressure is, roughly speaking, more than half that of the chamber from which the jet is issuing. Hence, after passing the contracted section the velocity will continue to increase and the steam to expand down to the pressure of the receiving medium.

As it is of the greatest importance to give to steam nozzles correct proportions, and, so far as the present writer is aware, the method of designing them has never been published, we will investigate their theory somewhat closely.

Let v = velocity in feet per second.
p = pressure in pounds per square foot.
u = volume of 1 lb. of fluid in cubic feet.
ρ = density.

$D = g\rho$ ($g = 32{\cdot}2$) = weight of 1 cubic foot of fluid in lbs.
A = area of cross section in square feet.
t = time in seconds.
M = lbs. passing any cross section per second.
W = work done per lb. of fluid in foot lbs.

Consider the steady flow of an elementary stream of the steam, the quantity passing all cross sections will be the same.

Consider the forces on the two faces of a given mass of steam enclosed by two parallel cross sections, distant from one another δx (Fig. 7). The pressure intensities on the two faces will be p and $p + \left(\frac{dp}{dx}\right)\delta x$. The volume enclosed between the cross sections is $A\delta x$, and its mass $\rho A\delta x$.

Then we have

$$\rho A\,\delta x\left(\frac{d^2x}{dt^2}\right) = -A\left(\frac{dp}{dx}\right)\delta x$$

therefore $\frac{d^2x}{dt^2} = -\frac{1}{\rho}\frac{dp}{dx}$;

integrating, we have

$$\frac{1}{2}\left(\frac{dx}{dt}\right)^2 = -\int \frac{1}{\rho}\frac{dp}{dx}\frac{dx}{dt}\,dt + \text{constant},$$

$$= -\int \frac{1}{\rho}\,dp + \text{constant},$$

but $\frac{dx}{dt} = v$, and $\frac{1}{g\rho} = u$,

therefore $\frac{v^2}{2g} = -\int u\,dp + \text{constant}.$

Now, $\int u\,dp$ is the work done during the expansion and $\left(\frac{v^2}{2g}\right)$ is the kinetic energy, hence we see that the increase in kinetic energy equals the work done during expansion.

If the equation for the expansion is given by pu^n = constant, or its equivalent $p^m u$ = constant (C), where m is the reciprocal of n, then we know that between the pressures indicated by the suffixes 1 and 2, and assuming for simplicity that the initial velocity is zero, we have :—

$$\frac{v^2}{2g} = W = \frac{p_1u_1 - p_2u_2}{1 - m}$$

$$= \frac{C(p_1^{1-m} - p_2^{1-m})}{1 - m}$$

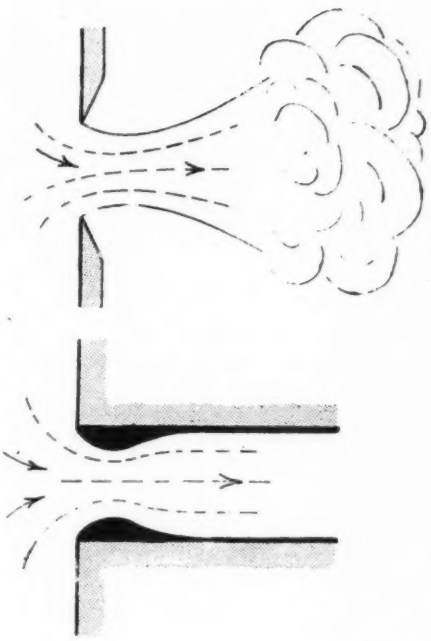


FIG. 6.

This equation can be written in other forms for convenience in special cases.

The writer has determined the values of n for different conditions as to pressure and dryness of the steam.* The results are given in the accompanying table :—

Table I.

Dryness.	Pressure, Lbs. per Sq. In. (absolute).					
	250	200	150	100	50	20
1·0	1·13	1·133	1·135	1·14	1·145	1·15
0·9	1·12	1·122	1·125	1·125	1·13	1·135
0·8	1·11	1·11	1·113	1·115	1·117	1·12
0·7	1·10	1·1	1·1	1·103	1·105	1·105

The properties of superheated steam are still not known with any certainty. Using Professor Callendar's results, the writer

* *The Engineer*, April 10th, 1903: "Curves showing the Adiabatic Expansion of Steam."

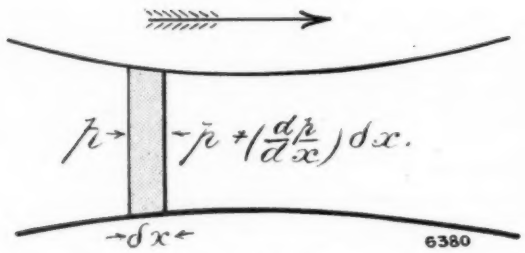


FIG. 7.

constructed an entropy diagram and obtained a value of n equal to 1·28 approximately.

A truly-shaped nozzle should have the same cross section as one of the elementary streams, and in order to keep its skin friction low the cross section should—if otherwise suitable—be circular. Neglecting friction losses, we find, first, that the quantity of steam (including moisture) passing all cross sections is the same, hence:

$$A = \frac{M}{vD} = \frac{Mu}{v} = \frac{MC}{vp^m}$$

hence $$\frac{A}{A_o} = \frac{v_o}{v}\left(\frac{p_o}{p_3}\right)^m$$

where the suffix o denotes the least cross section.

Now A is a minimum (and equal to A_o) when vp_o^m is a maximum, that is, when $(vp_o^m)^2$ is a maximum. Now—

$$(vp_o^m)^2 = C\,2g\,p_o^{2m}\,(p_3^{1-m} - p_o^{1-m})$$

hence differentiating with respect to p_o and equating to zero, we see that at the least cross section we have—

$$\frac{p_o}{p_3} = \left(\frac{2}{n+1}\right)^{\frac{n}{n-1}} = \left(\frac{2m}{1+m}\right)^{\frac{1}{1-m}}$$

Table II. gives the results for various values of n; p_3 is the steam chest pressure.

Table II.

n	1·10	1·11	1·115	1·12	1·133	1·145	1·15
$\left(\frac{p_o}{p_3}\right)$	·598	·592	·588	·585	·583	·580	·578

For superheated steam $\left(\frac{p_o}{p_3}\right) = ·552$.

We are now in a position to design the complete nozzle. As an example, we will assume a stop-valve pressure of 215 lbs. per square inch absolute, back pressure (exhaust) 1 lb. absolute; nozzle to deliver 535 lbs. of dry steam per hour. From Table I. we see that $n = 1·133$, and hence $p_o = 125·3$ lbs. absolute; also $v_o = 1490$, and v_2 (velocity of delivery) is 4030. Hence

$$\frac{A_2}{A_o} = \frac{1490}{4030}\left(\frac{125·3}{1}\right)^{\frac{1}{1·133}} = 26·3.$$

That is, the final area of cross section of the nozzle is 26·3 times the least area of cross section, and the diameter 5·13 times the least.

If the back pressure had been 15 lbs. absolute the pressure at the least cross section would be unaltered, but the final velocity would only be 3,190 ft. per second, and hence the final area of cross section would be 3·03 times the least, the final diameter being therefore only 1·742 times the least. The large increase in the final diameter when used condensing is obvious.

In both cases the least diameter will be $\frac{1}{4}$ in. It is obtained from the formula previously given—

$$M = \frac{A_o v_o}{u_o}$$

The sizes of these nozzles must be very carefully designed, a slight error in the least diameter will considerably affect the steam passing, unless throttling is resorted to, which is uneconomical.

Nozzles for Superheated Steam.—Readers will find the entropy diagram useful in this respect. Let p_s be the pressure at which the steam becomes just saturated, and p' the initial pressure at the steam chest. Then if p_s is less than ·552 p' the pressure p_o at the least cross section will occur whilst the steam is still superheated. If otherwise, then the steam will be met by the time it reaches the least section, and we have, assuming saturation has been reached,

$$\frac{v^2}{2g} = \frac{p'u' - p_1u_1}{1 - \left(\frac{1}{1\cdot28}\right)} + \frac{p_1u_1 - pu}{1 - m} = K + W,$$

where K is a constant for the particular conditions To determine the pressure at the least cross section we proceed as for saturated steam and find that

$$\left(\frac{n+1}{2}\right)p_0^{\frac{n-1}{n}} = p_1^{\frac{n-1}{n}} + P,$$

where $P = \dfrac{K}{2g\,C}$, and where, as before, $C = p_1^{m}u_1$.

The other data can be calculated as for saturated steam. The entropy diagram will be found useful in determining p_1. In this connection we need to draw in constant-pressure lines for superheated steam. Using Professor Callendar's results, the writer has found that approximately:

$$\phi = 1\cdot15 \log\left(\frac{T}{500}\right) + 1\cdot35 \times 10^{13}$$
$$(500^{-5\cdot5} - T^{-5\cdot5})$$

where ϕ = increase in entropy from 39 degs. Fahr. = 500 degs. Fahr. absolute, and T = absolute temperature in Fahrenheit degrees.

No other lines on the entropy diagram beyond those on the ordinary saturated steam diagram are necessary in this connection.

If, instead of varying the back pressure for the nozzle, we had varied the steam-chest pressure, we should find that approximately the quantity discharged and the reaction at the nozzle are proportional to the absolute pressure, which agrees with the experimental results obtained by Professor Ewing and Mr. Rosenhain, thus affording valuable evidence in favour of the above theory.

As affording further evidence, the velocities obtained experimentally by Mr. Rosenhain are plotted (Fig. 8), together with those calculated from the above theory. The back pressure is one atmosphere. The close agreement between theory and practice is at once evident. Curve *C* gives the calculated results, curve I. those for a thin-lipped orifice, curves III., IIIA., and IIIB. for a conical nozzle, taper 1 in 12, and a rounded inlet to the least cross section. Curve III. is for the original nozzle, IIIA. for the same, with about half the delivery end cut away, and IIIB. when still more of the nozzle was cut off. At low pressures the simple orifice is the most efficient, having practically no skin friction; at higher pressures it apparently gives incomplete expansion, resulting in eddies in the jet and lateral expansion. Nozzle IIIA. gives better results than its original, III., due probably to the reduced skin friction; IIIB. has less skin friction than IIIA., but apparently it is too short to give complete expansion. Careful experiment is necessary in order to secure the best results.

As the steam nozzle is often used for estimating the steam consumption of a turbine, it is desirable to know the effect of the initial dryness of the steam. The velocity of discharge will be approximately proportional to the square root of the dryness, and since the density is inversely proportional to the dryness, the discharge

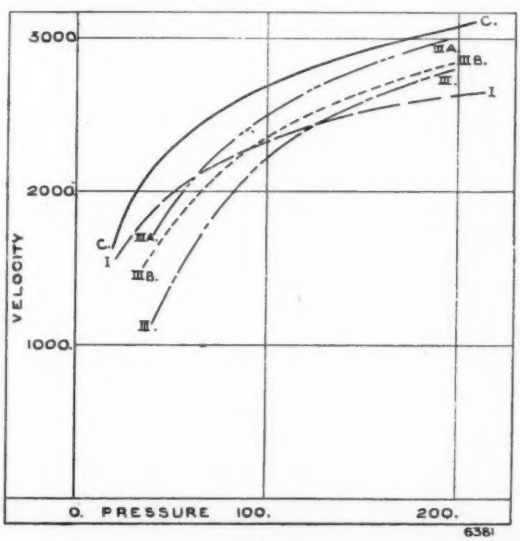


FIG. 8.

of a given nozzle should be approximately inversely proportional to the square root of the dryness. Calculated accurately by our formulæ we find this to be true, so that evidently in estimating the discharge from a nozzle we should know the dryness at the steam chest.

Fig. 9 shows the distribution of pressure, velocity, and moisture (per cent.) in the nozzle, working between pressure limits 215 and 1, steam initially dry.

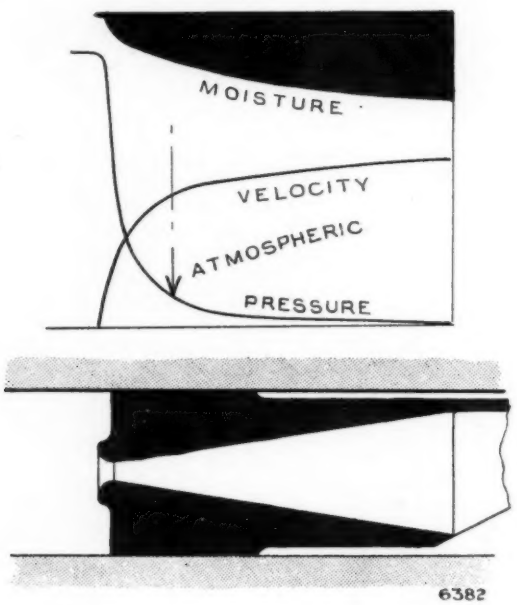


FIG. 9.

Modern Woodworking Machinery.

By M. POWIS BALE, M.Inst.C.E., M.I.Mech.E.

(Continued from page 316.)

Section III.—Steam Mortising, Boring, and Tenoning Machines.

MORTISING machines may be divided into three classes: (1) Those with a reciprocating motion; (2) Those with a rotary motion; (3) Chain-cutter mortising machines.

Reciprocating machines are most largely employed, and are constructed with a positive or graduated stroke to suit different classes of work. For working soft woods positive-stroke machines are largely employed; but machines arranged to work with a graduated stroke undoubtedly possess advantages over a machine with a positive stroke, but more especially with hard wood. The object of the graduated stroke is, of course, to allow the chisel to enter the wood gradually, and so relieve the machine and the foot of the operator from vibration, and remove the tendency to bend the chisel or jam and split the wood. Except with heavy positive-stroke machines, the chisel is usually brought into action by a treadle, the chisel connections being lengthened as the chisel is depressed, and the chisel commencing gradually from a still point above the upper throw to the full length of the stroke. The objection to this arrangement is the multiplication of the working parts; to withstand the increased wear, these should be made of steel and phosphor bronze, and be extremely well fitted.

To prevent the jar of the chisel striking the wood reaching the operator, some American makers connect a sliding friction-plate to the treadle. For door, sash, and light work generally in soft wood, a graduated stroke is not necessary, an ordinary treadle movement for bringing the wood up to the chisel being sufficient.

In the construction of vertical reciprocating mortising machines it is important that the main column be of ample strength to overcome the vibrations from the stroke of the chisel; and for this purpose a hollow column with an extended base is to be preferred.

When working hard wood it is necessary that a clearance hole is first bored for the chisel; this is usually done by a boring-spindle combined in the machine and mounted in an exact line with the chisel, which can be arranged to reverse automatically if desired. When a machine is required for railway carriage or wagon or similar heavy work, it is often fitted with a supplementary rotary mortising or routing apparatus; this usually receives in addition a horizontal reciprocating movement from a disc-crank fitted with an adjustable crank-pin, by which means the length of the traverse of the cutting-tool can be regulated. As regards mortising chisels, the best with which we are acquainted for general purposes is a double-lipped chisel with serrated back, and with the lips tapered outwards on the inside from the points upwards, which allows increased clearance for the core as the chisel passes further into the wood, and draws the core from the mortise on the up stroke, leaving the sides of the mortise clean. Hollow square chisels, with an auger arranged to work inside them, are also used for boring and squaring at the same time.

For slot or rotary mortising work the most recent type of bit is one formed of L-shaped cutters, in which the upper part is let into the steel shank, the horizontal part pointing inwards and reaching as far as the centre line of the bit. The cutters

are sharpened on one vertical and one horizontal edge, and cut at the bottoms as well as the sides of the mortise. These cutters are much quicker in operation than the ordinary spoon bit, and are easily sharpened or replaced. Another form of slot mortising tool is used considerably in America, in which the twist is formed into a number of chisel-shaped lips, rising from the edge of the twist, and presenting sharp edges in the direction of the bow, so that the wood is cut laterally if traversed against it.

When machines are used for mortising the hubs of wheels a modification in the construction of the table is necessary. The usual plan is to fix the hub between headstocks mounted on a compound sliding-table, working beneath the chisel and boring auger. One of the headstocks is fitted with a dividing or index plate, which automatically spaces the mortises required, and obviates the necessity of setting them out by hand. The mortises can be made either straight or "staggered," and by means of a canting-table and stops any desired "dish" can be given to the mortises, and their length accurately gauged. The chisel should be self-coring, and be arranged to reverse automatically or by hand.

A chain-cutter mortising machine has lately been introduced for light work, in which cutters are used instead of chisels. These are mounted, according to the width of the mortise desired, as a vertical revolving chain, which is worked by a sprocket-wheel, and brought down into the wood, through which the cutters work their way. It is claimed for this arrangement that no boring is required, and there is no reversing on short mortises.

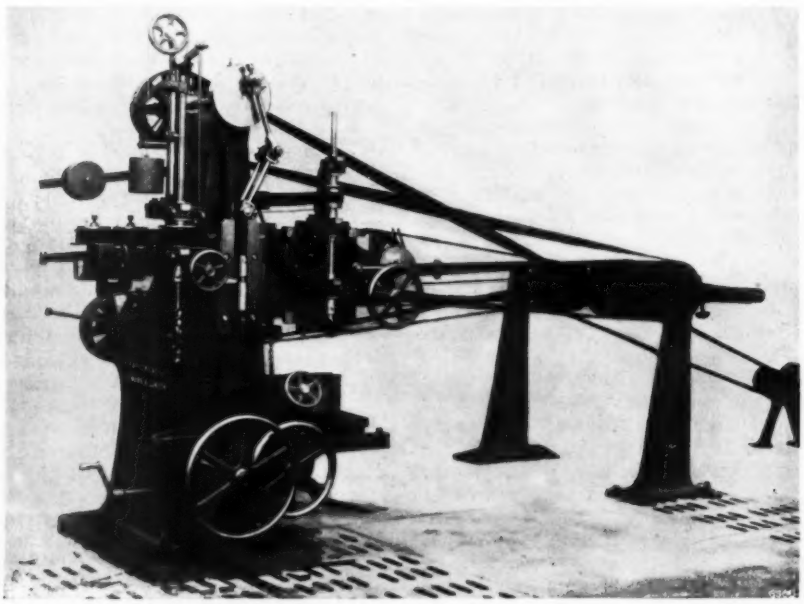


FIG. 25.—COMBINED MORTISING, BORING, AND BOXING MACHINE.

Speed of Mortising Chisels (Reciprocating).

It is impossible to lay down absolute rules as to speed, as it will depend on the size and type of the machine and nature of the work. The following are, however, given as a guide: Machines to mortise up to—3 in. wide, 175 to 275 strokes per minute; 1 in. wide, 200 to 300 strokes per minute; 1 in. (movable table) 275 to 400 strokes per minute.

Speed of Rotary Mortising, and Boring Bits.

Mortising bits—for soft wood, 2,000 revolutions per minute; hard wood, 1,200 revolutions per minute. The speed is decreased in proportion as the size of the bit increases.

Fig. 25 illustrates a combined mortising, boring, and boxing machine for railway carriage and wagon, and other heavy work, by Messrs. A. Ransome & Co., Ltd., Newark-on-Trent.

In cutting the mortises the wood is first of all operated on by a routing-tool, arranged with a rotary motion, the ends of the mortises being afterwards squared out by a reciprocating chisel driven from a disc-crank at the top of the machine. In this machine the upper part of the standard which carries the cutting-tools and their gearing is arranged to slide on the fixed bed in a transverse direction to the length of the timber to be mortised; and this motion being worked by power, the tools can be readily brought to any desired position over the wood, thus enabling a sole bar to be mortised, bored, and recessed without any lateral adjustment. The squaring-out chisel has a variable stroke, which is regulated by a treadle movement, and is so arranged that when the foot is removed from the treadle the reciprocating motion of the chisel ceases. The table carrying the wood is fitted with vertical, lateral, and transverse adjustments. The stroke of the adjustable disc-cranks driving the chisel and routing tool can be readily varied. The routing tool can also be used for boxing, recessing, or cross-grooving.

Fig. 26 represents a steam mortising and boring machine with automatic slot-mortising apparatus attached, by Messrs. John McDowall & Sons, Johnstone. This machine is adapted for railway carriage and other heavy work. The main frame of the machine is of hollow core section, and cast in one piece, to which is attached boring and slot-mortising apparatuses driven from countershafts placed at the

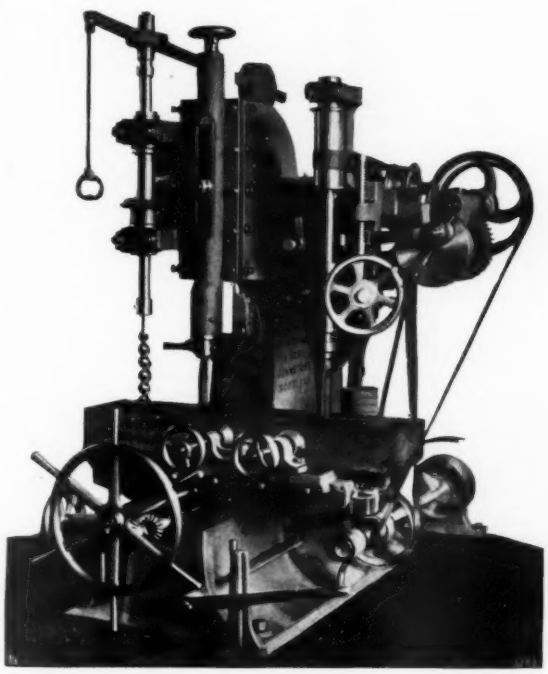


FIG. 26.—STEAM MORTISING AND BORING MACHINE.

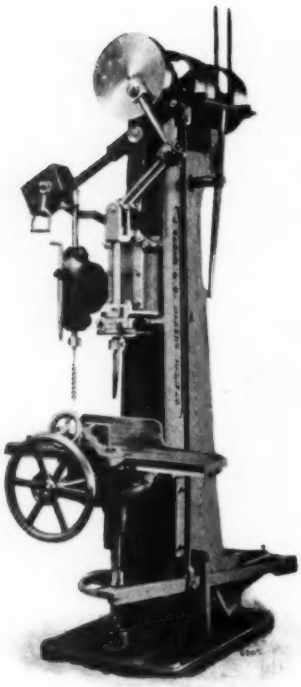


FIG. 27.—GRADUATED STROKE MORTISING AND BORING MACHINE.

base of the standard. The table carrying the wood is arranged with horizontal and transverse adjustments, of sufficient travel to allow of double mortises being formed in large pieces without turning them end for end. The depth of the mortise is regulated by means of a hand-wheel and screw, and the horizontal traverse of the supplementary routing-tool by an adjustable crank-pin. The slot-mortising tool can also be used for recessing and other purposes.

Fig. 27 represents a steam-power mortising and boring machine with graduated stroke, by Messrs. J. Sagar & Co., Ltd., Halifax. The standard is a hollow casting made in one piece. The chisel is arranged with a graduated stroke, and is worked down into the wood by means of the treadle bar shown, and rises to the "still" position when the operator's foot is removed. The bracket carrying the table is adjustable vertically by means of hand-wheel and screw; and an arrangement is fitted for reversing the chisel automatically when one end of the mortise is completed. A boring apparatus is fitted in line with the mortise chisel.

Fig. 28 shows a chain-cutter mortising machine by Messrs. Thomas Robinson & Son, Ltd., Rochdale. The table carrying the wood is fitted with vertical and transverse adjustments worked by hand, wheel, and screw. The cutter-chain is driven and supported at its upper end by means of a sprocket-wheel; whilst its lower end passes round a friction pulley mounted on the end of a guide-bar, which can be readily adjusted to give the required tension to the chain. The cutter-chain is usually sharpened by an emery-wheel

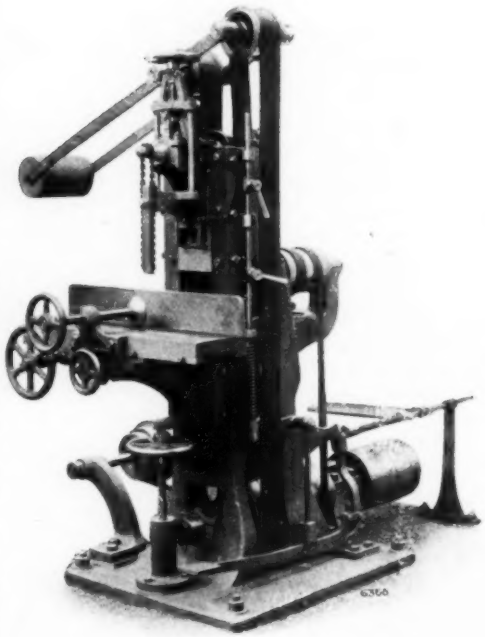


FIG. 28.—CHAIN-CUTTER MORTISING MACHINE.

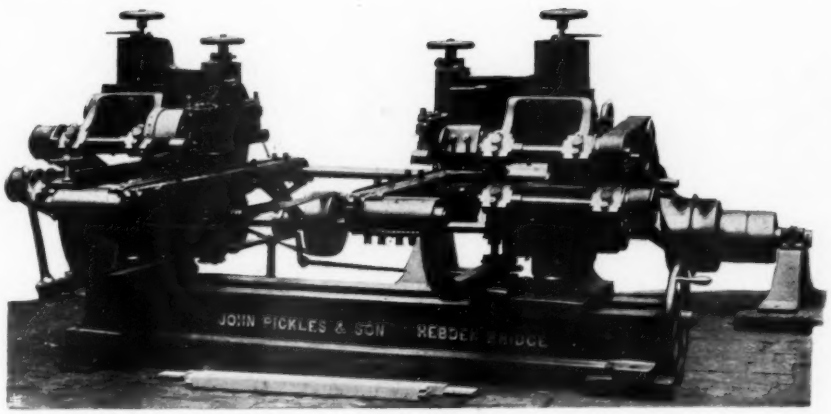


FIG. 29.—DOUBLE TENONING MACHINE.

mounted in a simple apparatus designed for the purpose.

By pressure of the foot on a treadle the chain-cutter is made to descend into the wood, and cuts the mortise at one operation, at the same time throwing out the core.

Tenoning Machines.

Although saws or cutter-discs are still sometimes used for cutting tenons, they have generally given way to cutter-blocks and cutters working horizontally across the grain of the wood, the shoulders being formed at the same time by segmental cutters. A pair of cutter-blocks is used, and the wood is fixed on a sliding-table and passed between them when a single tenon is formed. Should it be required to cut double tenons a supplemental vertical spindle carrying a wing cutter-head or "drunken" saw is fitted immediately behind the two horizontal cutter-spindles. The main frame of this machine, with bed and stand for table, should, by preference, be cast in one piece. The sliding-brackets carrying the cutter-spindles should be adjustable vertically and also transversely, to enable tenons with unequal shoulders to be cut. The cutter-spindles should be of steel, and run in long bearings of phosphor bronze. Three sets of bearings are now often fitted. By making the top cutter-block movable, and substituting for it a circular saw or grooving head, it can be used for cross-cutting, grooving, trenching, etc., as may be required. The traversing-table is made to run on rollers in planed ways, and fitted with an adjustable cramp for holding down wood, setting out gauges, etc. The table should be sufficiently heavy to prevent all springing when the wood is cramped down and under the operation of the cutters. If the cutter-spindles are driven by an "in-and-out" belt, arrangements should be made for keeping it at a uniform tension; but heavy machines are better driven by separate belts direct from a countershaft. Straight cutters are employed, and are mounted on blocks at an angle so as to give a shearing cut.

A vertical scribing-spindle can be fitted to tenoning machines with great advantage; it should have both vertical and lateral adjustments, and run in conical bearings. In addition to tenoning, with a few extra fittings these machines can be made to do a considerable variety of work. The driving pulleys should be wide, and with only a very moderate degree of rounding. If there be much rounding, the driving power of the belt is considerably reduced, unless the belt be specially shaped to the arc of the pulley.

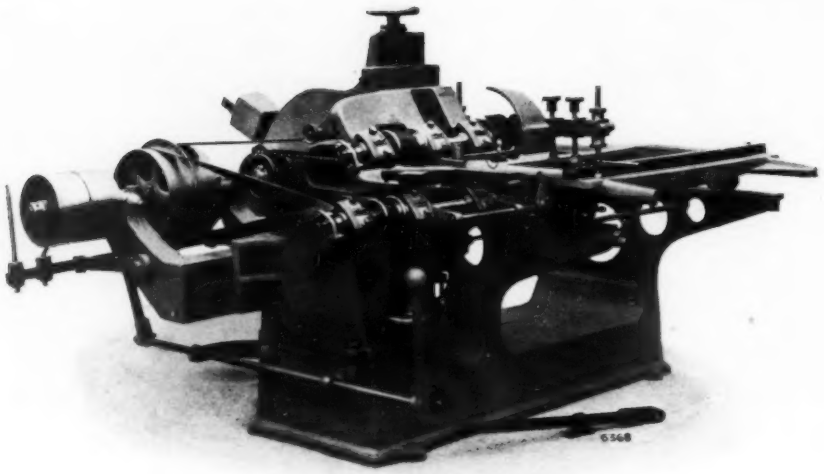


FIG. 30.—TENONING MACHINE.

Tenoning Machines for Railway Carriage and Wagon Work.

Various modifications of ordinary tenoning machines are in use for cutting single or double tenons on the sides, bearers, and diagonals of the under-frames of railway carriages and wagons. As a heavy table is required for this work, it should be arranged with an automatic traversing motion, and, unless a double-ended machine is employed, it can be arranged to swing with advantage. The table should be made wide enough to take, say, four wagon soles at once, and double tenons can be cut on them at one traverse of the table past the cutters. The table can then be swivelled round, and during its backward traverse tenons are cut on the opposite ends. Tenons on the diagonals can also be readily cut by this arrangement. The middle of the three cutter-blocks should be made movable, and the machine can then be used for rebating the ends of the soles.

An extra slide carrying a cross-cut circular saw can be mounted on this machine with advantage, so that all the pieces of timber can be cut to one exact length at the same time that the tenons are being cut.

Speed of Tenoning Machine Cutters.

Heavy machines 2,500 to 4,000 ft. per minute at the cutting edge; light machines 3,000 ft. to 4,500 ft. per minute at the cutting edge.

Fig. 29 shows a double tenoning machine with scribing apparatus by Messrs. John Pickles & Son, Hebden Bridge. This machine has been designed for use in establishments requiring a large amount of tenons cut. The machine consists practically of two separate tenoning machines, one of which is a fixture to the bed, and the other has a horizontal traverse along it by means of a hand-wheel screw. Consequently, the machines or head-stocks can be set any desired distance apart, and tenons completed on both ends of a piece simultaneously in one passage through the machine. The sliding brackets carrying the cutter spindles have independent vertical and lateral adjustments, and are provided with a locking arrangement to keep them in any desired

position. Vertical scribing spindles, adjustable vertically and laterally, are also fitted to each headstock. The wood is carried through the cutters by an automatic double endless-chain arrangement, and is held steady whilst under the operation of the cutters by an adjustable pressure-apparatus.

Fig. 30 illustrates a tenoning machine by Messrs. J. Sagar & Co., Halifax. This machine is adapted for general tenoning, scribing, cross-cutting, grooving, trenching, etc. Both horizontal cutter-block spindles are arranged to run in three bearings of phosphor-bronze, one being placed on each side of the driving belts. They are adjustable vertically, and have setting-out gauges for the first tenon, also for distance between the shoulders. In combination with a vertical spindle, not seen in the illustration, tenons can be made and the shoulders scribed at the same operation. Double-tenons, angle-tenons, and tenons with unequal shoulders can also be made. Differing from the usual practice, the travelling table in this machine is made heavy instead of light, a combination of roller bearings being fitted to give an easy traverse, and it is claimed that increased stability and capacity for doing accurate work is thus gained. For cross-cutting or grooving a circular saw or grooving block is substituted for the tenoning block on the top spindle.

Industrial Combines in Scotland.

By BENJAMIN TAYLOR.

QUITE a number of industrial combinations have been formed in Scotland during the past two or three years. This, perhaps, is not surprising considering that Glasgow is the place of origin and of management of the most successful and most profitable organisation of the kind ever attempted on either side of the Atlantic; namely, the Cotton Combine, conducted under the name of J. & P. Coats, Ltd. That, however, is a combination which does not concern us here. The movement in industries of interest to readers of this journal may be said to have begun in 1900 with the formation of the Rivet, Bolt and Nut Co., Ltd. This was the amalgamation in one company of practically all the rivet, bolt, and nut makers of Scotland. The firms included were John Bilsland & Co., Glasgow; Clyde Rivet Works Co., Glasgow; Edward Crosher, Glasgow; William Crosher & Co., Glasgow; Walter Donald & Co., Easterhouse; Dundee Rivet Works Co., Dundee; Hunter, Hardin & Wilson, Glasgow; James Kennedy, Coatbridge; Macfarlane Bros., Glasgow; Alexander Pillans, Motherwell; James Rose & Sons, Govan; James Smith & Co., Rutherglen; Sunnyside Rivet Co., Coatbridge. The amalgamation would have placed the monopoly of the production of bolts, nuts and rivets in the Clyde district (which, of course, is an enormous consuming market) in the hands of the combine, but for one thing—the shipbuilders did not fancy this elimination of competition in the supply of material so important to their industry, so they got up a little combine of their own in the shape of the North-West Rivet Co., to erect new works and produce rivets, etc., on the most approved plan for the shipbuilding shareholders of Scotland. In this case combination created competition. The Rivet, Bolt and Nut Co. has a capital of £550,000 in £10 shares, one-half ordinary and one-half preference. The aggregate purchase-price of the several vendors was £460,780, of which £275,000 was paid by allotment of the ordinary shares, fully paid up, and the remainder in cash out of the proceeds of the preference shares, which alone were offered for public subscription. The shipbuilders' rivet combine is the North-West Rivet, Bolt and Nut Factory, Ltd., with a capital of £50,000 subscribed by the shipbuilders of the Clyde alone. No shares were offered to the public, and no accounts are published.

The arrangement between Vickers, Sons & Maxim, Ltd., Barrow, and William Beardmore & Co., Ltd., Glasgow, was neither in the nature of an amalgamation nor of a "Trust" on the American pattern. It was a commingling of interests and an exchange of risks for joint benefit. And while it explained some of the wild stories of "Combines" that had been previously circulated, the original design was, we believe, of much wider import than that actually accomplished. It is a combination under one control, or, at all events, of one "community of interests," of three shipyards and three engineering establishments, formerly accustomed to compete with each other for Admiralty contracts. It is not to be supposed, of course, that warship building for the Admiralty is always profitable. On the contrary, the Thames Ironworks Company and the predecessors of Messrs. Beardmore in their shipbuilding business could tell a different story. It gives, however, great prestige to a yard, which is very useful in its general business, while it requires a perfection of plant and an efficiency of equipment that demand large financial resources. The Vickers Company created 400,000 more ordinary shares, transferred, fully paid, to Mr. William Beardmore in exchange for one-half the ordinary shares in his company. The private firm of William Beardmore & Co., which had been in existence for some eighty years or more, was registered as a limited liability company, with a share

capital of £1,500,000 in ordinary shares of £1 each, and with borrowing powers to the extent of £2,000,000. The old firm of William Beardmore & Co. had been making certified profits to the extent of £140,000 per annum, which is good enough to pay 8 per cent. on the ordinary share capital and to leave a margin for reserves.

From a small forge or foundry business the Beardmore concern has attained gigantic dimensions, and especially within the last ten or a dozen years. The main parts of the business are steel making and casting, armour-plate making, shipbuilding, and engineering. Ordnance making has only just begun, and has not got much beyond the experimental stage yet. But powers are taken to extend, by acquiring and working coal mines and quarries, and to undertake contracts for works involving supply or use of machinery, the construction of roads, railways, tramways, telegraph lines, etc., and to acquire docks, buildings, and patents, etc.

The simple explanation of this alliance is that the Vickers Company wanted another assured outlet for their chief material. They make plates, but not the heavy armour-plates which are now a speciality of the Beardmore works. They make gun-mountings, but not the heavy guns that the Beardmore Company will make. They also make lighter plates and other material that the Beardmore Company do not make. Thus each finds a customer for some of its products in the other.

Another recent combination is that of the businesses of A. & J. Stewart and Menzies, Ltd., Glasgow, and of Lloyd & Lloyd, Ltd., Birmingham. Both were steel-tube manufacturers, and each in itself represented a previous combination. Thus A. & J. Stewart & Menzies, Ltd., was the lineal successor of A. & J. Stewart & Clydesdale, Ltd., which in turn was a joint-stock formation of the businesses of A. & J. Stewart, iron founders and iron- and steel-tube manufacturers at Glasgow and Coatbridge; of Stewart Bros., iron and steel-tube manufacturers, Coatbridge; and the Clydesdale Iron and Steel Tube Co., Mossend, near Glasgow. This combination was formed in 1890, and in 1898 it was enlarged by the absorption of the business of James Menzies & Co., of the same trade in Rutherglen and Glasgow, whose name was added to that of the extended company. The capital then became £850,000, in shares of £10 each, of which £500,000 was in ordinary shares, all issued and paid up, and £350,000 in 6 per cent. cumulative preference shares, with a priority as to capital. Of the ordinary shares £50,000, and of the preference shares £50,000, were paid over in the acquisition of the business of James Menzies & Co., Rutherglen. By that acquisition A. & J. Stewart & Menzies, Ltd., became the largest tube manufacturing concern, not only in Scotland but also in Great Britain. The originator of this great business was Mr. Andrew Stewart, who, forty years ago, founded the Clyde Tube Works on the site now occupied by St. Enoch Station of the Glasgow and South-Western Railway Co. The Stewart & Menzies Co. owned eight extensive works, covering in the aggregate 85 acres of ground and employing over 6,000 workers. With the business of James Menzies & Co. the company acquired plant for the manufacture of seamless (or solid drawn) steel tubes, in which a great trade is now done. Subsequently works were erected for the manufacture of the machines and tools required by the company in its several factories. Three years ago the company built the Imperial Tube Works at Airdrie, which made them the largest makers of tubes (boiler, gas, water, steam, etc.) in Europe, and the makers of the largest variety of tubes in existence. Besides the share capital above-named, there were debentures to the amount of £200,000. The reserve fund was £209,000, and the depreciation fund £160,000.

The concern known as Lloyd & Lloyd, Ltd., of the Albion Tube Works, Birmingham, was formed, in 1898, to acquire certain tube businesses in that city. The principal works are there, and the company was the largest maker of tubes in England. The capital was £450,000 in £10 shares, of which £300,000 were ordinary. There were also £150,000 of 4 per cent. mortgage stock debentures.

All the ordinary shares, £84,150 of the preferences, and £68,500 of the debentures were issued to the vendors and their friends. It was said that the Lloyd family practically held all the shares in this concern, the chairman of which, Mr. J. H. Lloyd, was of the family of the founder of Lloyds Bank. The connection of Lloyd & Lloyd, Ltd., with Scotland, is that a few years ago they acquired a large interest in the Clydesdale Tube Co, Coatbridge, of which they latterly assumed the control. This work was started by some of those who had been concerned in the operations of A. & J. Stewart & Menzies, and it has been the means of bringing the two large producers into actual "community of interest." The Stewart & Lloyd combination, it will be seen, is an extensive one, and brings under one control the larger portion of steel tubes made in this country. The capital involved is £2,000,000.

Another amalgamation may be regarded as a sequel to the "community of interests" formed between Vickers, Sons & Maxim, Ltd., of Sheffield and Barrow, and William Beardmore & Co., Ltd., of Glasgow. On the same lines, and to meet similar conditions, John Brown & Co., Ltd., of Sheffield and Glasgow, have combined with Thomas Firth & Sons, Ltd., Sheffield. That is to say, John Brown & Co. acquired seven-eighths of the ordinary shares of Firth & Sons in return for 90,000 of their own ordinary shares of £1 each, fully paid, and 24,000 preference shares of £10 each, fully paid, transferred to the Firth Company. The profits of the Firth Company justified this exchange of capital, while the amalgamation has a direct commercial value. For instance, John Brown & Co., who are armour-plate makers at Sheffield, are also shipbuilders near Glasgow, in the yard founded and carried on for many years by the late firm of J. & G. Thomson. At this yard is done a large amount of business for the British Navy, and there also have been built a number of warships for Japan, Spain, Greece, etc. Though John Brown & Co. build and provide the material for building steel armour-plated vessels, they do not manufacture many of the lighter qualities of steel, and they do not make ordnance, gun-mountings, and projectiles. These last, however, are made by the Firth Company, a concern which was founded some sixty years ago, which was the first private manufacturer of ordnance, and which is remarkable for the high quality of its hard-steel castings. It was founded by the late Mark Firth, who gave to Sheffield a park, a college, and a number of almshouses. The Ard works in Sheffield are adjacent, and the product of these, combined with the yard at Clydebank, enable the new combination to turn out a warship complete with their own material, from keel to casemate, and from donkey-engines to loaded guns.

With the Brown-Firth combination, the Vickers-Beardmore alliance, and the Armstrong-Whitworth Co., we now have in this country three separate establishments, each capable of constructing a complete warship. And this is certainly a matter of great interest and importance to the nation and the Empire.

A Scotch Coal Combine followed upon occasional reports of a projected acquisition of the Scottish coalfields by an American syndicate, headed by Mr. J. Pierpont Morgan. Why Americans should desire coal-mining properties in this country, and why of all parts they should select the Scottish coalfields, is not explained. What eventuated was neither a Combine on the "community of interests" principle, nor an incorporation on the principle of the American Steel Trust. Nor had Mr. J. P. Morgan anything to do with it beyond financing the Debenture Bonds. What was done was to enlarge the sphere of United Collieries, Ltd., by the annexation or absorption of some three-and-twenty other colliery concerns—some large, some small, some limited companies, and some private enterprises — and to bring the whole organisation under Glasgow management with Scotch capital, although the intermediary work was effected by a syndicate of London and Glasgow capitalists. The United Collieries, Ltd., whose headquarters are in Glasgow, was formed in 1898, and had a capital of £300,000 in £1 shares, half cumulative preference, and half ordinary shares, the amount called up on

which was £275,000, for amalgamating a number of colliery companies and firms. By development this company reached an output of about 1,000,000 tons per annum, and paid dividends at the rate of 10 per cent. for 1898-99, 20 per cent. for 1899-1900, and 25 per cent. for 1900-1901, all of which years formed an exceptionally prosperous period in the coal trade. The pits of the United Collieries, Ltd., are all in the Lanarkshire area, whose chief outlet is the port of Glasgow, but which has also cheap direct railway communication with the ports of Grangemouth and Bo'ness, on the East Coast. The major portion of the old output, however, went into home consumption.

This company was, in 1902, enlarged to take over from the Collieries Consolidated Syndicate, Ltd., of London, a number of collieries which they acquired contiguous to the pits of United Collieries, Ltd. For this purpose United Collieries, Ltd., increased its capital to £3,000,000 by an issue of £1,000,000 in debentures, by raising the preference capital to £1,000,000, with a cumulative dividend of 6 per cent., and by increasing the ordinary share capital to £1,000,000. The price paid for the twenty-three collieries was £2,275,000, and there was a further outlay of some £175,000 for wagons. After deducting the existing capital of United Collieries, the new combination had a free working capital of about £300,000.

While a number of the concerns absorbed were small and unknown to fame, there were also several well-known firms taken over. The estimated annual output of the combine (including, of course, that of the former United Company) is 6,000,000 tons; that is, roughly, about one-third of the output of the Lanarkshire area, which includes Dumbarton and Linlithgowshires, but not Ayrshire. The output of all Scotland in 1901 was 34,162.094 tons, and the output of the area in which the collieries of the new combine are situated is about 18,000,000 tons. To that output the great iron companies possessing their own pits contribute about 6,000,000 tons, of which they consume about one-half, sending the other half into general consumption. The coal-producing iron companies are also buyers as well as sellers of coal.

Thus, then, this combination, with a nominal capital of £3,000,000, controls one-third of the output of the largest coalfield in Scotland and one-sixth of the whole output of Scotland. About one-fifth of the output of Scotland is exported; that is to say, not much more than the production of the combine. The chief qualities produced from these collieries are house, steam, and splint coal, the latter being the kind of coal used at the blast furnaces and ironworks, and their principal markets are at home. It has not, however, been very successful, and the issue of its first report and balance-sheet has aroused a storm of controversy into which it is not desirable to enter in these pages.

The locomotive makers of Scotland next agreed to combine into one company with a capital of £2,000,000, of which £1,000,000 was in shares allotted to the vending companies in payment of their plant, machinery, and other fixed assets, and £1,000,000 in 5 per cent. cumulative preference shares were for public subscription. The concerns amalgamating were Neilson, Reid & Co., Dubs & Co., and Sharp, Stewart & Co., Ltd., all of Glasgow. The first two were private firms, the last-named was a limited company with a capital of £300,000, which, since 1895, had paid dividends of from 6 per cent. to 15 per cent. per annum, had accumulated a reserve fund of £35,000, and had allotted £40,000 in bonuses to its ordinary shareholders, in addition to the dividends. The capital and profits of the two private firms are, of course, not known, but they were both highly prosperous, up-to-date concerns; the originators of them all left large fortunes, and the vending proprietors were men of wealth.

It may here be noted that Glasgow is the largest producer of locomotives in the United Kingdom. There are in the United Kingdom eleven firms devoted to the manufacture of railway engines. Four of these, however, including one near Glasgow, make colliery and contractors' locomotives, and occupy rather

a different place from the other seven, who manufacture for public railways at home and abroad. These seven firms alone, apart from the four smaller firms, and from the output of the great railway companies, have an annual capacity of 1,170 engines per annum, and of this 1,170 or so the three Glasgow works now forming the combine produce over 600 per annum. This, it should be explained, is the capacity of the plant in the production of the many different types which a British locomotive builder is called upon week by week to produce; but it is estimated that if standardisation were adopted here as it is in America the output of British locomotive works could be trebled, with very little alteration of plant.

The firm of Neilson, Reid & Co. were the largest producers in Europe, and their works are as perfectly equipped and as efficiently planned as any factory in the world. These works are arranged for continuous, systematic progression, without block or deflection, from the issue of the order from the counting-house to the drawing-office, until the engine steams out of the erecting shop. This concern was founded away back in the 'thirties of last century by the family of "hot blast" Neilson, but it was chiefly developed under the capable management of the late Mr. James Reid, who became its active head in the 'seventies. He succeeded the former manager, Mr. Henry Dubs, who in the 'sixties left Neilson & Co. and started a works of his own. Then Dubs & Co. became second only in dimensions to Neilson, Reid & Co. In the 'eighties one of the Neilsons left the firm of Neilson, Reid & Co., and organised the Clyde Locomotive Co., Ltd., which erected a new set of works. In the course of three or four years, however, this concern was bought up by Sharp, Stewart & Co., Ltd., a Manchester firm of locomotive and machine-tool makers, who thereupon transferred their business to Glasgow. These are the three concerns, whose early histories were so much inter-related, which are now conjoined in the North British Locomotive Co., Ltd., in a combine formed with a view to reducing costs of management and sale, economising in the purchase of material, and presenting an effective front to the competition of American and German makers in colonial and foreign markets. Each one of these shops, in plant, equipment, and factory management, will compare with the best to be shown in America, but it is doubtful if there is a locomotive shop in all America that could turn out as many types of engines in the same time as any one of these shops can do.

The combine of Scotch locomotive builders was registered as the North British Locomotive Co., Ltd., with a capital of £2,000,000 in 100,000 5 per cent. cumulative preference shares of £10 each, and 100,000 ordinary shares of £10 each. All the ordinary shares were paid to the vendors in part payment of the purchase price, and also 2,000 of the preference shares. The vendors were allowed to subscribe for 23,000 of the preference shares, 50,000 were offered for public subscription, and the rest are held in reserve. The works are all in running order and capable of producing 600 locomotives per annum. Extensions are in progress for increasing the output and for increasing standardisation. Nothing was paid for goodwill or current contracts. The prices paid to the vendors for sites of works, erections, plant, and machinery (but not work in process or material) were £466,316 to Neilson, Reid & Co., £313,684 to Dubs & Co., and £240,000 to Sharp, Stewart & Co.

What effect these various combinations have had upon each industry, or upon the trade of the districts concerned, it is not easy to determine at this juncture. In fact, the condition of industry has been declining so much of late that the situation is much obscured. There is not much room for doubt that the rivet combine would have operated on the cost of shipbuilding had the shipbuilders not taken defensive action; but, as it is, prices are probably on about the same range as if there had been no combination. The shipbuilding combines have had the effect of economising costs of production in the particular lines associated with the companies, but cannot be said to

have influenced the shipbuilding industry as a whole. The general result is one of increased efficiency. The tube combine makes also for economy and efficiency in production, though it may also obstruct or deter the competition of minor producers. As far as can yet be gathered its influence has been for good, both in the trade and for the shareholders. The colliery combine has been unfortunate in having had nothing but bad times and declining markets since its formation. It has certainly not succeeded in strengthening prices, and there is yet no evidence if the expected economy in management and administration has been realised. The locomotive combine improves the position of the Scotch makers to deal with American and German competition, and since it was formed the number of foreign and colonial contracts secured has been numerous. Overhead, one would be disposed to regard the effect of the combines as industrially good.

NOTES ON LOCOMOTIVE AND RAILWAY ENGINEERING.

By CHARLES S. LAKE.

FOLLOWING upon the illustration and brief description of the steam motor car for the Taff Vale Railway which appeared in the April Notes, and in accordance with the announcement then made with regard to the publication of further illustrations and particulars, these are commenced in the present issue.

The sectional drawings clearly illustrate the construction of the engine, boiler, and other vital portions of the design; and it will at once be seen that considerable ingenuity has been displayed in meeting the special conditions governing the case.

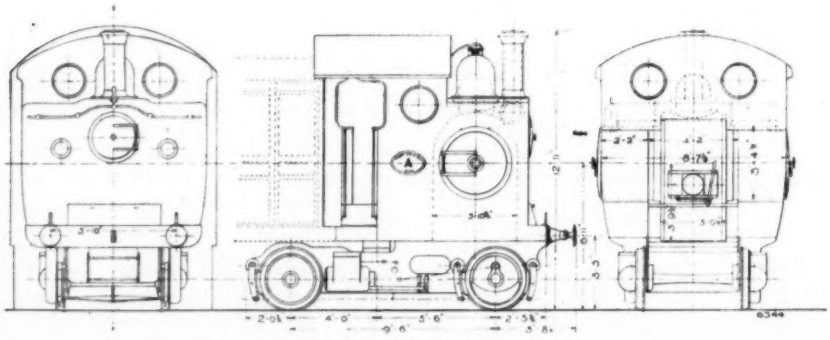
The boiler is of the multitubular type, and is constructed of steel plates, with a copper firebox. There are two barrels, containing 156 brass tubes each, and two smokeboxes.

The dome is placed over the firebox and the safety-valves, which are of the Ramsbottom type, are mounted upon it. The throttle-valve is opened and closed by means of a short lever, to which a cord is attached. This cord is carried along to the other end of the car, so that the engine may be operated from either end. Another cord is provided for the purpose of sounding the whistle from the platform at the rear of the car.

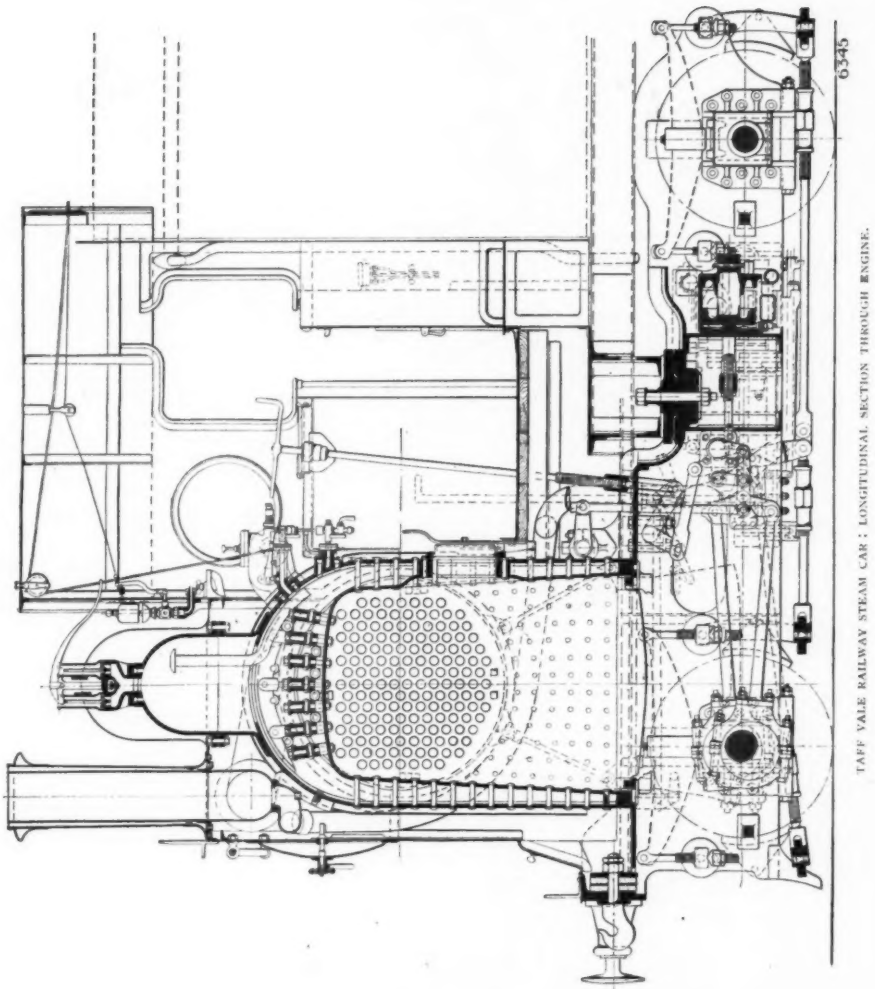
The drawings are self-explanatory, and if they are carefully examined not only may the design of the boiler, but also the arrangement of the engine, valve-gear, and brakework be easily followed.

Similar details, showing the construction of the car body, underframe, etc., will appear in next month's notes, together with a few statistics relating to the working results obtained, which Mr. T. Harry Riches, M.Inst.C.E., Locomotive Superintendent of the Taff Vale Railway, has kindly supplied in addition to the drawings.

The paper on Compound Locomotives in France, which was read before the Institution of Mechanical Engineers in March last, formed a valuable contribution to contemporary knowledge on the subject with which it dealt. The author, M. Edouard Sauvage, Consulting Engineer to the Western Railway



TAFF VALE RAILWAY STEAM CAR: FRONT, SIDE, AND BACK ELEVATIONS.

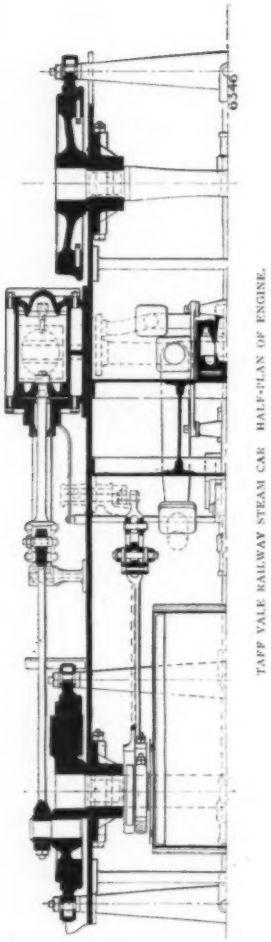


TAFF VALE RAILWAY STEAM CAR: LONGITUDINAL SECTION THROUGH ENGINE.

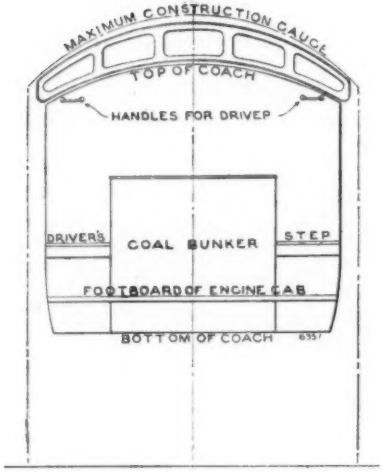
of France, is, of course in a position to speak authoritatively upon such a matter as the position of the compound principle in that country, and to forecast with tolerable certainty the future developments in store for what has become the predominant feature of French locomotive practice.

The paper, if carefully read, should suffice to convince the most strenuous opponent of locomotive compounding that the principle advocated, not only by M. Sauvage but also by the majority of prominent engineers upon the continent, is by no means the fad that some on this side would have us believe.

The French have every claim to be considered far ahead of ourselves in this important matter of compounding. The results they have obtained are the out-



TAFF VALE RAILWAY STEAM CAR: HALF-PLAN OF ENGINE.



TAFF VALE RAILWAY STEAM CAR: DETAILS OF PRESSED STEEL FRAME FOR BACK OF CAB.

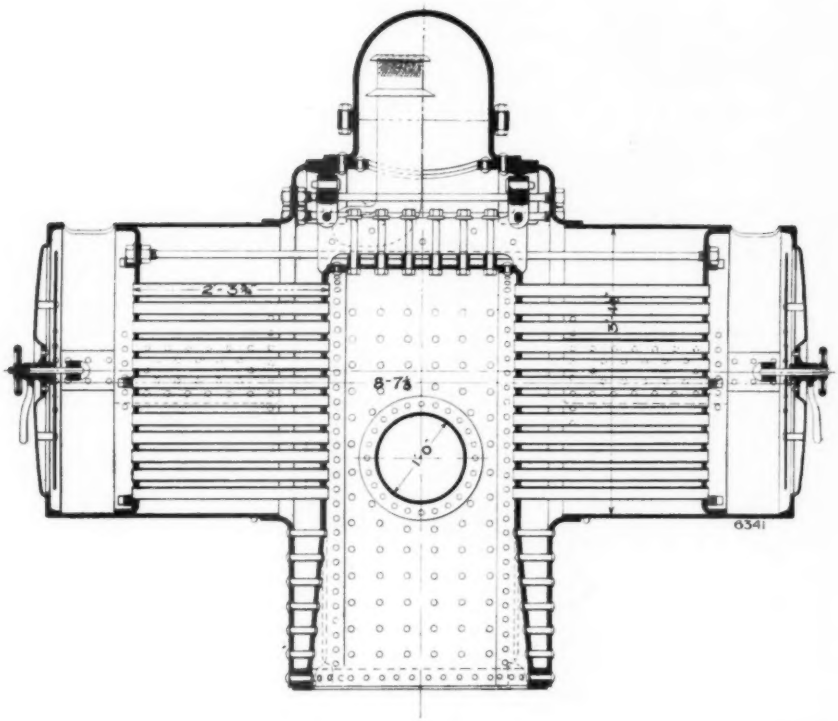
come of scientific investigation, experiments conducted without prejudice and an impartial enquiry into the whole subject in which neither individuality nor bias of any kind has been allowed to stand in the way of a complete understanding of the merits of compounding.

The author of the paper presented a large amount of valuable data in support of his contentions, specifying the results obtained on various leading French railways, and quoting the opinions held by such well-known locomotive engineers as MM. du Bousquet Moffre, Baudry, and Salamon, upon the subject of compounding, all of which, as may be supposed, are strongly in its favour. In speaking generally upon the matter at the conclusion of the paper, M. Sauvage pointed out that:

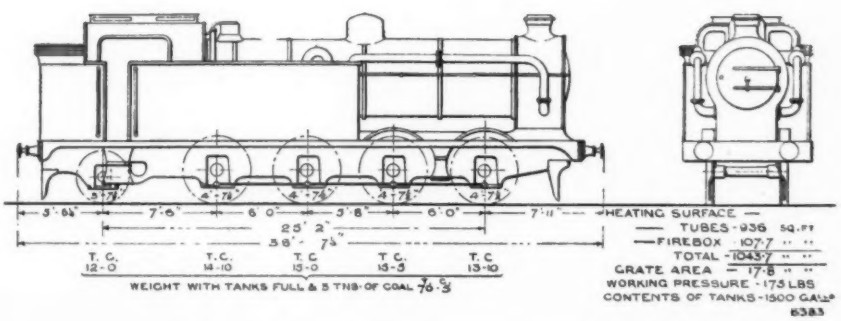
"Owing to the adoption of compound locomotives by the railways of France, the weight and speed of the trains for goods, as well as for passenger service, had been increased without any large increase of coal-consumption per kilometre run. In fact, it was rather under-estimating the merits of the compounds to say that by their use the weight of the trains had been increased by one-third with the same cost of fuel over what it was with the best simple engines used before; or, if not the weight, speed was increased, and in many cases both weight and speed."

"Simple engines," he said, "might be made with the same large boiler and work with the same high pressure, but it seems clear that with the ordinary valve-gear of the locomotive steam at such a high pressure cannot be as well utilised as by compounding; there is little doubt that the simple locomotive would require more steam for the same work, or give less work for the same quantity of steam."

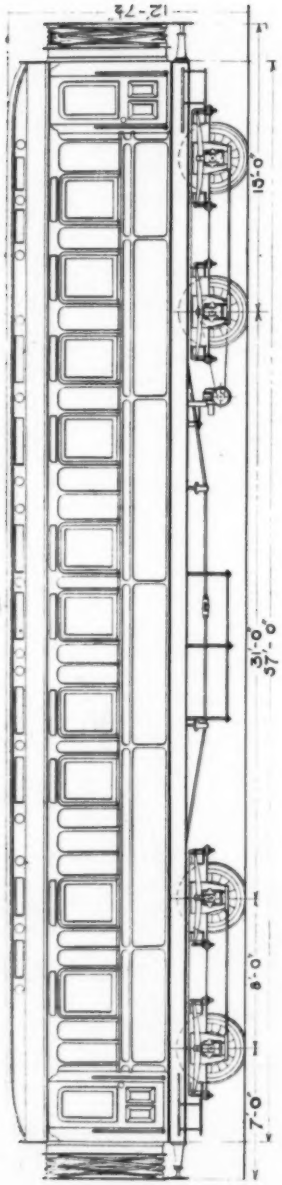
"A complete solution of the problem would require a proof that the results obtained with compound locomotives might not be obtained in some other way. Available data are not sufficient

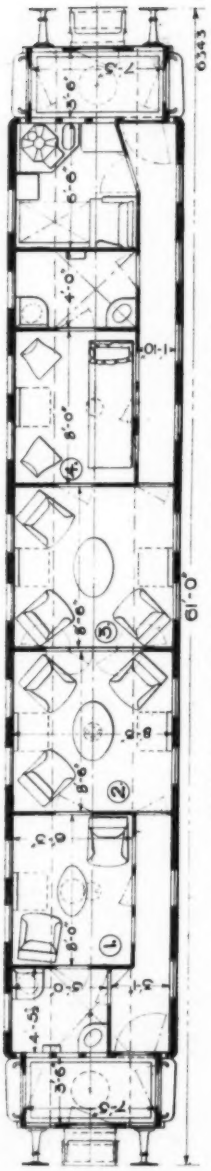


TAFF VALE RAILWAY STEAM CAR: DETAILS OF BOILER.



GREAT NORTHERN RAILWAY EIGHT-WHEELS-COUPLED RADIAL TANK ENGINE.





LONDON AND NORTH-WESTERN RAILWAY COMPANY: ROYAL TRAIN SALOON.

to give such proof in an incontestable manner; still, it seems difficult to build an ordinary locomotive quite equal in every respect to the latest compounds."

With this last remark the majority of those who took part in the discussion seemed quite in accordance. At any rate no such simple engine has up to the present been produced. The new 4–6–0 type locomotive recently built at Swindon works from the designs of Mr. G. J. Churchward, Locomotive Superintendent of the Great Western Railway, is perhaps as well suited as any simple engine to compete favourably against the de Glehn compound on the same railway. The English engine has two 18 in. by 30 in. outside cylinders, coupled wheels 6 ft. 8 in. diameter, a total heating surface of 2,143 sq. ft., and a working steam-pressure of 225 lbs. per sq. in. The large heating-surface and high steam-pressure will be greatly in its favour; and, should it prove successful in the trials about to be made, the inference will be that it is owing to the presence of these features that such success has been achieved.

* *

Reference was made to the eight-wheels-coupled radial tank engine for the Great Northern Railway in the March Notes, when dealing with the matter of

suburban railway traffic and the difficult problems which it presents. By the courtesy of Mr. H. A. Ivatt, Locomotive Superintendent to the Great Northern Railway, it is now possible to illustrate the design, which possesses many interesting features.

As originally constructed the new tank engines differed somewhat from their present condition, as they were fitted with slightly heavier boilers, and the side tanks were extended so as to cover three pairs of coupled wheels instead of two. As thus arranged they were found to be in excess of the total weight which it was considered desirable to place upon certain sections of the permanent way over which they had to travel, and as a consequence they were altered and are now as illustrated. The cylinders are inside the frames and they drive the second pair of coupled wheels. The valves work above the cylinders through the medium of rocking levers, the gear being of the ordinary Stephenson link pattern.

With an average cylinder pressure of 160 lbs. per sq. in. the tractive effort of the engine is about 30,000 lbs., which is considered sufficient to accelerate a train of 250 tons weight at the rate of 1·5 ft. per second, so that a speed of 30 mls. per hour would be reached within half a minute of starting on the level.

These engines are giving every satisfaction in working, and as a result of their introduction it is confidently believed that the "suburban traffic problem" on the Great Northern Railway has been solved for some time to come.

* *

The writer has received from Mr. C. A. Park, M.Inst.C.E., Carriage Superintendent of the London and North-Western Railway, several drawings and photographs showing the general arrangement and external appearance of the new saloons which have been built from his designs to run with the Royal Train, already constructed at Wolverton Works.

The new vehicles are magnificently appointed in every way, and are second only to those used by their Majesties the King and Queen. There are six of these saloon carriages, and they are all of the same dimensions, corresponding in profile to the Royal Saloons.

Each car can be arranged for day or night use, having four compartments, all of which may be adapted to the purpose of providing sleeping accommodation if necessary. Two of these compartments are larger than the others—viz. 8 ft. 6 ins. long by 8 ft. 3 ins. wide, against the 8 ft. by 6 ft. 3 ins. of the smaller ones.

The two larger compartments are so arranged that they may be readily converted into one saloon 17 ft. 2 in. long. The doors which divide them under normal conditions are arranged so as to fold back against the side of the saloon.

The principal outside dimensions are as follows:—Length, 57 ft. over balconies, 61 ft. over buffers, 9 ft. wide at the waist, 10 ft. 7½ ins. from rails to cornice, and 12 ft. 7½ ins. from rails to the top of clerestory roof. The sides are turned in from the waist to the cornice, in order to clear the loading gauge. The body of the saloon is carried on an independent underframe of steel and iron throughout, and mounted on two four-wheeled bogies of the L. & N.-W. standard pattern, with 8-ft. centres.

The structural framing of the saloon is principally of teak and oak, the outside being panelled with canvassed and blocked Honduras mahogany.

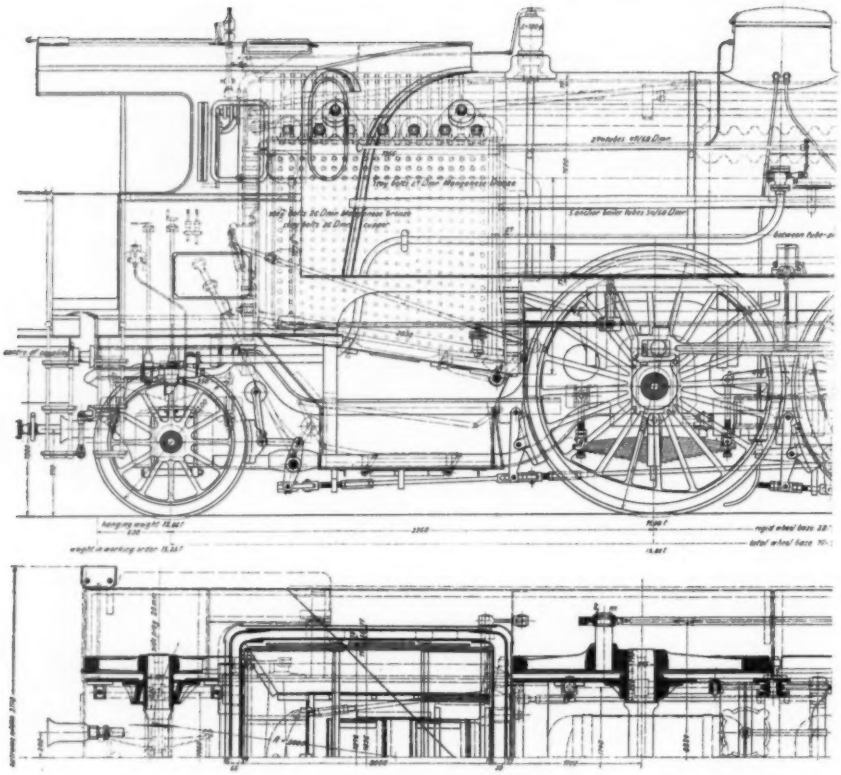
The saloons are lighted throughout by electricity, the current being generated by dynamos driven off the axles.

Heating apparatus is provided on the high-pressure system, having small pipes along the sides of the compartments from and to the stove, which are covered with ornamental cast covers and lacquered to match the linings The vehicles are fitted with the combined automatic vacuum and Westinghouse brakes.

The interior furnishing and fittings are of the most elaborate description, the general scheme of decoration being beautifully carried out on the most artistic lines.

* *

The twelve four-cylinder compound express passenger locomotives constructed



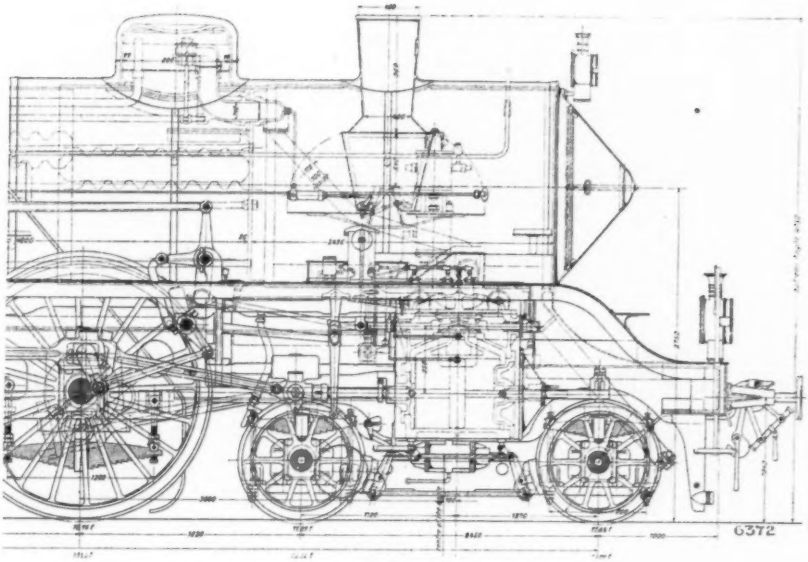
EXPRESS LOCOMOTIVE FOR

by Messrs. J. A. Maffei & Co., of Munich, for the Baden State Railways, are remarkable engines in every way. A brief reference was made to this subject in the Notes for December last, and an illustration showing the external appearance of the engines was included. The writer has received from the builders a complete specification of the design, from which the accompanying drawings are reproduced.

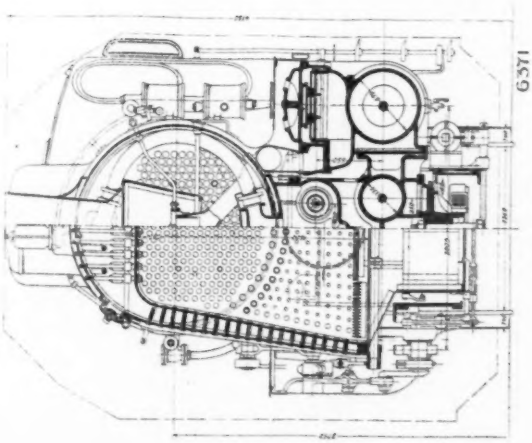
The four cylinders are in the same transverse plane, with the high-pressure between and the low-pressure outside the frames, all driving the axle of the first pair of coupled wheels. The high-pressure cylinders are cast in one piece with their steam chests, thus providing a means of rigidly staying the frames at that point, whilst the low-pressure cylinders are bolted to the outside of the frame plates, and are connected to the high-pressure by short double pipes.

Piston valves with inside admission are used for the high-pressure and balanced slide valves, on the Maffei-Wilson system, for the low-pressure cylinders.

The valve gear, which is the Heusinger modification of the Walschaert motion, is arranged outside the wheels and in such a manner that only two sets of gear are necessary for the four cylinders. A rocking shaft is used for actuating the high-pressure valves, and steam may also be distributed to the low-pressure cylinders



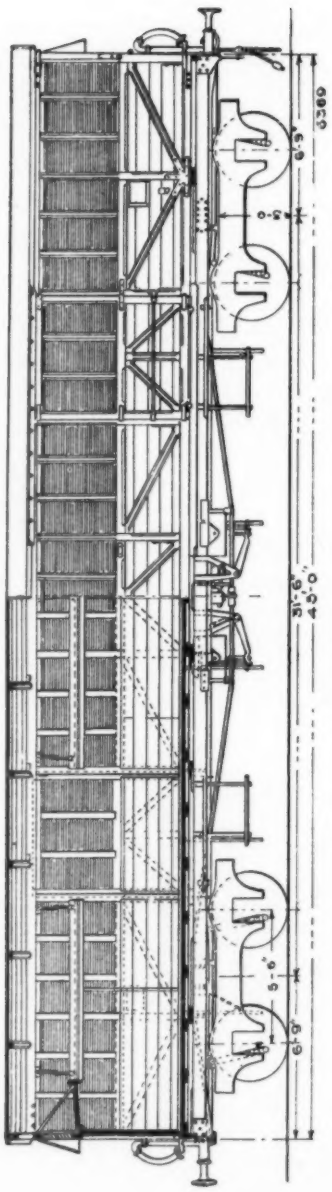
BADEN STATE RAILWAY.



CROSS SECTION.

direct, if required, by means of a special starting valve with which the engine is fitted.

The boiler is of large proportions, and is fed by two Friedmann injectors of the pattern known as S. Z. No. 11. The firebox, which is almost of square section, is supported by two sliding pieces fixed to the rear portion of the foundation ring, and resting upon a cross stay-plate. Guide plates are provided at the front of



GREAT CENTRAL RAILWAY FISH CAR: LONGITUDINAL SECTION.

the firebox outer shell to prevent side movements.

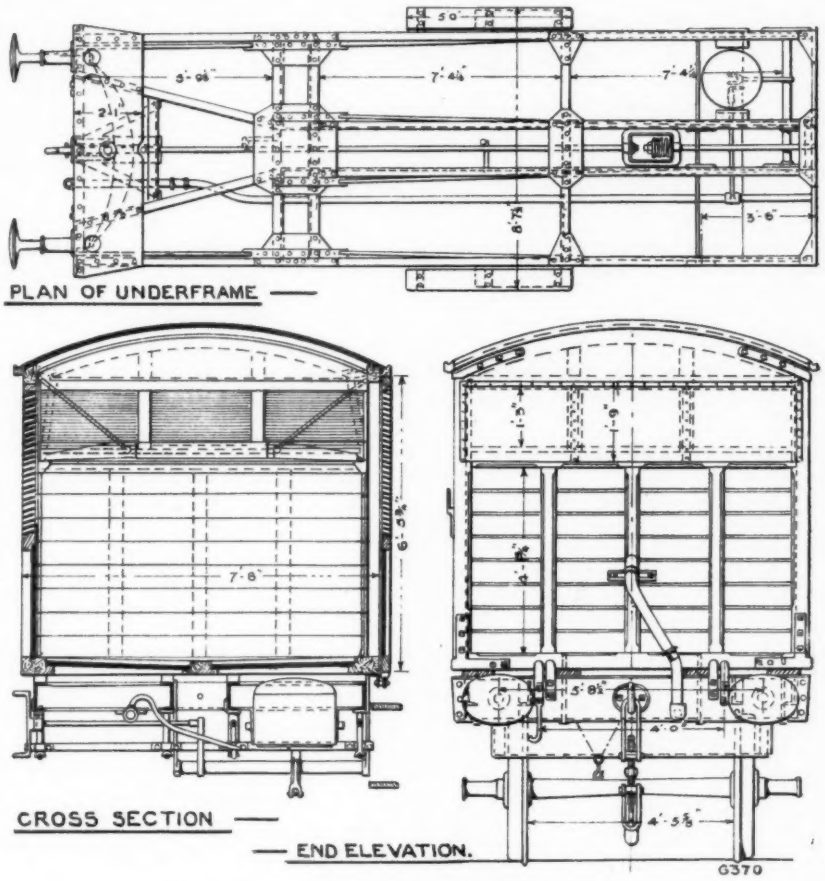
The firedoor consists of three wings, which can be turned inwards around a horizontal axle. There is a separate handle for each wing, by means of which the wing can be kept either open or shut. The central wing is moved automatically with each of the outside wings, but can also be opened by means of the handle. Thus, while firing, only two-thirds of the door are open. The central wing is used for admitting air on the top. With each half opening of the door a pendulum indicator is moved showing which side was fired last. The front part of the grate is made movable, and the ashpan consists of a lower casing and an upper division shaped as a funnel. This casing is fitted with a front and two bottom doors.

The smoke-box contains a "Sturm" type spark-arrester, in which the perforated plates at the front and back are closed automatically by a small steam cylinder as soon as the regulator is opened. When it is closed, however, the plates remain open in order that the gases may have a free escape. All the wheels on the engine are fitted with brake blocks, including those of the bogie truck. The tender is carried upon two four-wheeled bogies, and the total weight of engine and tender in working order is 122 tons. Messrs. Maffei & Co. state that during the trials which took place soon after the engines were completed, trains composed partly of double bogie carriages and partly of four-wheeled carriages, representing 40 axles and a total weight of 300 tons, were hauled a distance of 60·64 kilometres in 38 minutes, a speed of 95·8 kilometres per hour. The principal dimensions appear in metric figures on the drawings, the equivalents in English measure having been given in the December (1903) issue.

* *

Among the many up-to-date specimens of rolling stock which Mr. J. G. Robinson, Chief Mechanical Engineer to the Great Central Railway, has introduced upon that line are the fish wagons illustrated herewith.

The Great Central Company has developed a very important fast fish traffic between Grimsby and London, Manchester, Sheffield,



GREAT CENTRAL RAILWAY FISH CAR: CROSS SECTION AND END VIEW.

and other centres. In order to satisfactorily deal with the demand thus created it was found necessary to adopt a type of vehicle better adapted than the ordinary four-wheeled truck to the special conditions and requirements of this particular class of traffic, and as a result the vans under notice were constructed and placed in service.

The carrying capacity is 15 tons per wagon, and the over-all dimensions are as follows :—

	ft.	ins.
Length over headstocks	45	0
Width over pillars	7	8
Height inside at middle	7	2
Height inside to cant rail	6	0

There are two sliding doors on each side of the car, 4 ft. 11 ins. wide by 6 ft. high clear, to facilitate loading and unloading.

The floors are specially constructed to carry off drainings, and are so formed that the drippings are deposited between, instead of upon the rails, and thus considerable inconvenience with regard to following trains is avoided. The floor bearers are tapered towards the middle, and the floor boards are laid diagonally 1 in. below the top of the longitudinal and the bottom sides, and the space is filled up flush with marble cement 1 in. thick, so that the floor falls from the sides to the middle, where there are six brass

drains connected to pipes, 1 in. internal diameter. The upper portions of the sides and ends of the vans are formed with louvres, with perforated zinc sheets on the inside. Sheet-iron hoods are also fitted on the ends outside; thus ample ventilation is ensured, which is a very necessary measure in view of the description of traffic.

The under-frame is comprised of steel channels. The sole bars, diagonals, longitudinals, and the three intermediate cross bearers are 7 ins. by 3 ins. by $\frac{1}{2}$ in., and the bogie centre-bearers are 8 ins. by $3\frac{1}{2}$ ins. by $\frac{5}{8}$ in., placed back to back $9\frac{3}{4}$ ins. apart. The longitudinals are all trussed and connected to the cross members by knee-angles, top-plates, and $\frac{5}{8}$-in. diam. rivets.

Fox pressed steel trucks are employed. The stock is fitted with the automatic vacuum brake, and also an "either side" screw hand-brake. Trains consisting of 12 of these vehicles and one brake van are being regularly run between Grimsby and Marylebone on a fast schedule by Mr. Robinson's 4-6-0 type of engine, having 19 ins. by 26 ins. in outside cylinders, and coupled wheels 6 ft. 1 in. diam.

High-Speed Tool Steel.

By J. M. GLEDHILL, Member of Council Iron and Steel Inst.

THERE is no doubt that marvellous results are being obtained daily in machine shops all over the country as a consequence of the introduction of the new high-speed tool steels. The recent very complete series of tests carried out at the Manchester Municipal Technical Schools under the superintendence of Dr. Nicholson, Professor of Engineering at that institution,* proved to demonstration that it was economical to adopt high cutting-speeds, and a careful study of the results obtained should suffice to convert the most sceptical.

There are, however, within our own experience, many engaged in productive work who are yet doubtful, and who appear to be frightened by the prices asked for the new steel, an attitude which may be due to the fact that they have found themselves unable to obtain equal results to those obtained in special trials.

To those the following paper should prove interesting, inasmuch as the speeds and feeds daily in operation at a number of works are given. The paper was read by Mr. Gledhill (of Sir W. G. Armstrong, Whitworth & Co., Ltd.) before the Coventry Engineering Society in the lecture-room of the Technical Institute, Mr. Alfred Herbert presiding, and was illustrated by fractures of bars showing the various tempers and the effect on them by various heat treatments to which they had been subjected. Specimens of the important alloys used in the manufacture were also shown, and the current prices of these alloys showed very clearly the impossibility of producing high-speed steel at low prices, having regard to the costly nature of the materials used.—[*Ed.*]

* * *

The system of making steel in crucibles is by far the oldest of all others, and dates back from time immemorial.

What is known as "Wootz" steel, produced in India centuries ago, was made by melting small pieces of wrought iron together with pieces of wood and green leaves in a crucible, the crucible being made of earth and charcoal. "Wootz" steel at one time was imported from India for the manufacture of various cutting tools, and though the system is now practically extinct, it is still carried on in one or two districts to a small extent.

It was in Sheffield that crucible steel was first extensively and commercially manufactured by Benjamin Huntsman, during the year 1750, and it is to his skill in so doing that the world is indebted for one of its greatest industries.

As regards the present condition of manufacture, it has been proved from long and extensive experience that the finest qualities of crucible steel, which is required to cut to shape in our workshops the steel produced by other systems, can only be made by using the best brands of Swedish or Dannemora irons, and which, on account of their freedom from impurities—that is, their low percentages of phosphorus and sulphur—render them the most suitable for producing tool steels that will best retain their cutting edges. High percentages of phosphorus in tool steel (anything above ·03 per cent. phosphorus would be considered detrimental) is as opposed to good steel as fire is to water. Of course, these Swedish irons are expensive, and the process of converting them into steel is slow and costly, as only comparatively small quantities of steel can be produced, compared with the amount of fuel and labour expended. It therefore follows that the best brands of crucible steel must always command a high price, for it is impossible to satisfactorily produce them from inferior materials.

There are several grades or tempers of ordinary crucible steel, each being suited to its own particular class of work.

* Cf. Vol. IX., p. 541, and Vol. X., pp. 33 *et seq.*

It is usual to speak of these ordinary tempers or grades by numbers, as for example :—

No. 1 Temper, containing about 1·30 per cent. carbon, is suitable for small turning and planing tools, drills, and small cutters ; also for tools requiring the sharpest edges, razors, and surgical instruments. Great care must be taken not to overheat this quality.

No. 2 Temper, containing about 1·15 per cent. carbon, is suitable for heavier turning, planing, and slotting tools, drills, cutters, reamers, and engraving tools.

No. 3 Temper, containing about 0·90 per cent. carbon, is suitable for large circular cutters, reamers, taps and screwing dies, heavy turning tools, large drills, and taps.

No. 4 Temper, containing about 0·80 per cent. carbon, is suitable for cold chisels, hot setts, small shear blades, and large taps.

No. 5 Temper, containing about 0·75 per cent. carbon, is suitable for screwing dies, cold setts, hammers, swages, minting dies, miners' drills, smiths' tools, punches, and shear blades.

No. 6 Temper, containing about 0·65 per cent. carbon, is suitable for snaps, dies, cup drifts, hammers, and stamping dies.

"Vita" Brand is a very superior water-hardening steel specially adapted for finishing brass and steel at increased speeds in turret and capstan lathe work, and for turning chilled rolls and very hard materials.

"Dura" Brand is a special water-hardening steel suitable for ordinary drills, twist-drills, small mining tools, brass finishing tools, reamer blades, and wood-working tools.

It is very important to the producer that users of tool steel should state the purpose for which they require it, for it is obvious from the above grades that using, say, a No. 5 temper where a No. 1 is required, must be unsatisfactory alike to both parties, and often, in consequence, the steel is alleged to be bad and not unnaturally condemned ; whereas, the fact is really that it has been applied to a purpose it was not made for.

Before describing the process of crucible cast steel, it is perhaps desirable to define briefly some of the substances used in its manufacture, as well as certain technical terms.

Bar Iron, or wrought iron, is cast or pig iron which has had most of its carbon removed by smelting, either by puddling or other processes, and then rolled out into bars of a suitable section and length, to be afterwards cut into small pieces for charging into the crucibles.

Blister Steel is bar iron that has been heated for a long period at a high heat in a converting furnace in contact with carbon, the carbon gradually percolating into the bar, and the bar of iron thus becoming carburised. The surfaces of the bars, which were previously smooth, have become rough and dotted with blisters, due to the heat, and the fractured converted bar is quite different from the bar iron, as it has been converted to a more or less depth into steel. As the change goes on from the outside inwards, the conversion may go to a greater or less depth in the bar, or even right through it, so that we may obtain cemented bars of different grades steeled on their surface to varying depths, with an iron centre, or bars steeled throughout.

The grades of cemented steels usually made are :—

No. 1	containing	1·5	per cent.	of carbon.
No. 2	,,	1·25	,,	,,
No. 3	,,	1·00	,,	,,
No. 4	,,	0·75	,,	,,
No. 5	,,	0·625	,,	,,
No. 6	,,	0·50	,,	,,

Shear Steel.—The process of making this is as follows :—

Five short lengths of blister bar are heated in a hollow coke fire, which, by use of a soft blast, admits of being regulated to a welding heat. During this time the surface of the bars is covered with clay, beaten fine and applied during the heating, to exclude the air and prevent oxidation. The bars are then carefully hammered and welded together. This is known as "Single Shear" steel. To make "Single Shear" into what is known as "Double Shear" steel the bar made of "Single Shear," as above described,

is broken in the middle, the two pieces laid together, welded a second time, and again drawn to the required shape. By this double operation the steel becomes more homogeneous and of a finer texture, and we thus obtain a material having a hard and steely exterior, and yet possessing a soft interior, thus securing both hardness and ductility where required.

Spiegel Iron, or spiegeleisen, is a combination of iron and manganese in varying proportions.

One of the first considerations in the melting of crucible steel is the necessity of ensuring the crucibles used to be of the perfect quality requisite to withstand the very high temperatures required to melt the iron and various alloys; and especially is this the case in the melting of the ingredients of high-speed steels, which require extremely high temperatures to thoroughly assimilate and mix themselves into a homogeneous whole. This difficulty is only overcome by taking great care in their manufacture and by utilising only the finest qualities obtainable of the various materials. As the making of a crucible is an important business, it may be interesting to briefly describe it by the aid of the accompanying illustrations, which are reproduced from photos of the crucible department at the works of Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Manchester.

Fig. 1 presents a view of the various fireclays and compounds being carefully weighed, mixed, and trodden with the bare feet and balled, so as to thoroughly consolidate the mixture, and free it from air spaces, necessary to obtain the correct homogeneity required. The compound is then made into crucibles of the desired shapes and sizes, by hand, with the plug and flask. The operation of treading the clay with the bare feet may appear to the uninitiated to be a crude one, but mechanical ingenuity has so far failed to provide an equivalent substitute, trodden clay having been found to be more satisfactory in every way than clay treated mechanically.

Proceeding now to the manufacture of crucible cast-steel, it is necessary to first

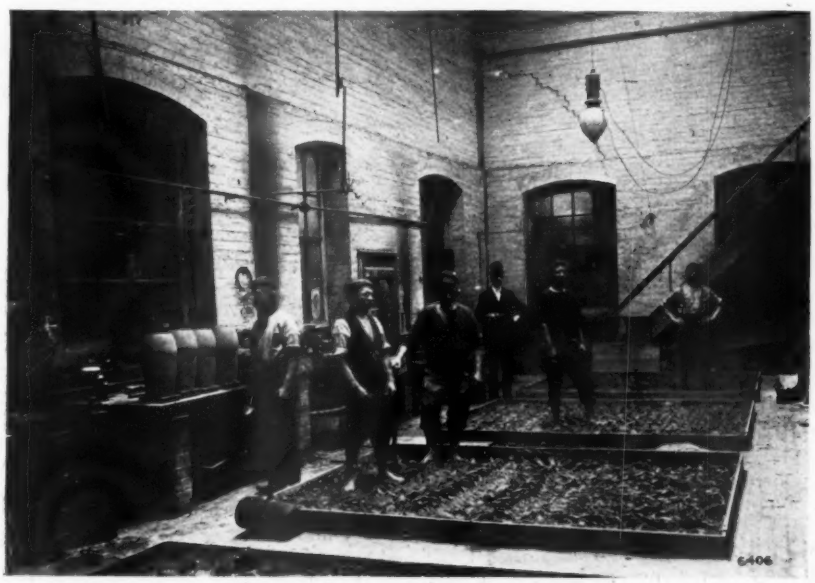


FIG. 1.—TREADING FIRECLAY FOR CRUCIBLES.

carefully select the blister or cemented bar according to the temper of steel required; and this having been done the bar is broken up into small pieces suitable for charging into the crucibles, about 56 lbs. of broken bar being generally charged into each, together with the alloys and other necessary substances for the particular temper of steel it is desired to make.

Before the crucible is put into the melting furnace, it has a preparatory annealing in a separate furnace, which is placed close to the melting furnace, so that the crucible is transferred from the former to the latter in a heated condition, this being done to prevent the too sudden heating of the crucible; for were it transferred directly into the melting furnace, it would be liable to fracture. The necessary charges being weighed out are now ready for putting into the crucibles, and are charged therein through a long funnel or bell-mouth tube. The melting holes are either heated by coke or by means of gas in a regenerative furnace, each division of such a gas furnace holding six or more crucibles. The process of melting occupies anything from 3 to 4½ hrs., according to the brand of steel being worked—the higher grade brands, such as high-speed steels, taking a longer time to melt and thoroughly mix the various alloys they contain.

The skill of the chemists and leading melters is now brought to bear on the important operation of melting, and the degree of heat of the furnace is regulated by them, the contents of the crucibles being inspected from time to time, so as to decide exactly when they are thoroughly mixed together. It is only by long and actual experience in melting that the correct condition can be ascertained as to when the steel is properly melted, and is just ready for pulling out and casting into ingot form. Before withdrawing the crucible containing the molten steel from the holes, which is done by a man called a "puller-out," he takes the precaution to envelop his legs with wrappers saturated with water, so as to prevent his apparel taking fire; but, should he do so, there is every convenience at hand, as a tank is provided close to the pot-holes, into which he can plunge and "extinguish himself."

This blister bar cannot be cut with the shears, as the bars are now hard owing to their being converted into steel. The pieces are now transferred to the metallurgical department, where the various irons, alloys, ferros, etc., etc., are carefully selected and weighed before being charged into the crucibles in the melting furnace.

Vanadium costs 40*s.* 0*d.* per lb., or £4,480 per ton; molybdenum costs 6*s.* 0*d.* per lb., or £672 per ton; tungsten costs 2*s.* 6*d.* per lb., or £280 per ton; nickel costs 1*s.* 6*d.* per lb., or £168 per ton, so that it will be seen where large percentages of such alloys are used that high-class crucible tool steel is naturally a costly production.

A few particulars of some of these alloys may also be of interest.

Fractures of Alloys.

(2) Ferro-Vanadium, 40%. (3) Ferro-Silicon, 30%.
(4) Metallic-Chromium, 98%. (5) Metallic-Manganese, 98·5%.
(6) Ferro-Molybdenum, 71·62%. (1) Wolfram, 41%. (7) Ferro-Tungsten.
(8) Tungsten, 98%. (8) Tungsten, 98%.
(9) Nickel, 99%.
(10) Ferro-Manganese, 80%. (12) Aluminium, 99·3%. (11) Ferro-Chromium, 67·5%.

Fig. 2 shows a general view of two sets of melting-furnaces, the fuel being coke. The crucibles are stacked on the shelves before being placed in the furnaces. On the left-hand side is a 24-pot furnace being charged with the mixing received from the weighing-room, each crucible, of course, being charged separately. The men may be seen stripping the moulds from the ingots and "topping" the ingots. By "topping" is meant the breaking off of the ingot-top, so as to reveal the fracture of the steel, and by which the expert can tell whether the melting has been good or bad, and the ingot fit for passing forward to the metallurgical testing department.

Fig. 3 shows a general view of a melting-furnace holding 36 crucibles. The furnace

FIG. 2.—COKE-FIRED MELTING FURNACES.

FIG. 3.—MELT NG FURNACE FOR THIRTY-SIX CRUCIBLES.

is divided into six divisions, and each division holds six pots. Each of the pots holds on an average 56 lbs. to 60 lbs., so that it will be seen in one round of melting about 1,800 lbs. of ingots are produced from such a furnace.

After passing through a department known as the tilting-shop, in which the ingots are re-heated in accordance with their different compositions and then cogged and hammered, they proceed to the annealing process, a very important branch of the business, especially to the users of tool steel. The very special brands of tool steel must not only be of the highest quality, but must be in such a state that they can be readily machined at the lowest possible cost to the many designs required for milling tools, boring tools, reamers, taps, dies, etc., and tools for delicate and very fine work. Another point of importance is the necessity of eliminating internal strains or brittleness which are set up in hammering, rolling, and finishing. The annealing brings the steel to a uniform and regular condition, so that when the steel is heated for hardening equal expansion is obtained, also equal contraction when cooled in the air blast, or dipped in water or other quenching liquids used for hardening. Further, the tenacity and life of the steel is considerably increased by the annealing process. This quality of tenacity is especially requisite in tools that encounter sudden shocks in the course of their work, such as slotting tools, or turning tools on work where the cut is intermittent, and where corners require turning off.

The cracking of milling cutters and other specially formed tools is a very expensive matter, owing to the great amount of labour and machine work that is put upon them. To minimise this cracking tendency in complicated tools, it is not only necessary to anneal the bar of steel in the hammered state from which the tools are made, but it is desirable, preparatory to hardening, that the cutter itself be re-annealed so as to enable the strains set up by machining to release themselves and leave the metal in a normal condition, and further to minimise the evil effects caused by expansion and contraction due to the irregular forms of cutters.

Intricate tools having sharp square bottom recesses, fine edges, or delicate projections, in which unequal expansion and contraction are liable to operate suddenly, are specially assisted by this second annealing. To demonstrate the effect of annealing, three samples have been taken from a steel bar, one being annealed and the other not. Also a test of "A. W." steel annealed. On being submitted to a mechanical test they gave the following results, which speak for themselves :—

No. 2. Not Annealed.	No. 2. Annealed.	"A. W." Annealed.
Yielding 30 tons ...	27 tons	—
Breaking 66·8 tons ...	42·5 tons	48·8 tons
Elongation 10·5% ...	24·5	20·5%
Reduction of Area 17%...	40%	22%

Fig. 4 shows the operation of emptying a furnace of annealed twist drills and cutter blanks.

It might, perhaps, be advisable at this stage to refer to the methods of forging and hardening tools made from the "A.W." steel. Having obtained the bar, it is necessary to cut off the required lengths; and this must be done at a forging heat. The lengths must not be broken off cold, as this tends to cause cracks in the bars. For forging, the steel should be placed in the fire and slowly but thoroughly heated, taking care that the heating has penetrated to the centre of the bar, and then forged at a bright red heat. Whilst forging the heat should not be allowed to get lower than a good red. After the tool is forged it should be laid down in a dry place and allowed to cool slowly. To harden the tool, the nose only should be gradually, but fairly rapidly, raised to a white melting heat, and then cooled with an air blast. If during this heating the point of the nose becomes fused or melted, no harm whatever has been done.

After grinding, which should be done on a wet stone, the tool is then ready for use.

FIG. 4.—EMPTYING A FURNACE OF ANNEALED TWIST DRILLS AND CUTTER BLANKS.

To obtain the maximum efficiency from the "A. W." steel it is essential that the nose of the tool shall be raised to a white melting heat as described.

Referring to the question of grinding the tools, nothing has yet been found to be so good for air-hardened steels as the wet sandstone, the tools being ground by hand thereon; but where it is desired to use emery wheels, users are recommended to adopt the system where the tools are roughly ground to shape on a dry emery wheel or stone before hardening. By this means the tool requires but lightly grinding after hardening, which should be done by hand. When the tools are ground on a wet emery wheel and undue pressure is applied, the heat generated by the great friction between the tool and the emery wheel causes the steel to become very hot, and water playing on air-hardened steel whilst in this heated condition tends to produce cracking.

(To be concluded.)

NEW MACHINERY & APPLIANCES

The Generation of Electrical Energy from Carbon.

DESPITE the fact that the numerous attempts made by various investigators, from Jablochkoff to Rawson, to solve the problem of obtaining electric current from carbon without the intermediation of the steam plant and dynamos, either by a thermo-electric or an electrolytic process, have all proved unsatisfactory from the commercial standpoint, there are, nevertheless, workers who are apparently not without hope of accomplishing what has proved impossible to their predecessors.

The earliest of the two latest cells, that of Mr. Hugo Jone, of Chicago, who published some particulars of his invention in the *Western Electrician* in November last, can hardly, however, be described as a "carbon cell" in the proper sense of the word. It does not differ from ordinary batteries with an alkaline electrolyte save that the positive zinc electrode is replaced by one of tin. In addition, however, the battery is furnished with an accessory apparatus, the function of which is to regenerate the tin by certain thermic reactions, and it is for this purpose that the carbon is supplied and consumed.

It is this regeneration of the tin by means of the heat used for heating the cell that forms the prime feature of the invention. Another point is the regeneration of the depolariser — mercuric oxide — from the metallic mercury obtained in the cell by the reduction of the depolariser. The mercury is converted into nitrate by treatment with nitric acid, which latter is again recovered by oxidising the nitrous vapours produced, in the presence of steam and atmospheric oxygen.

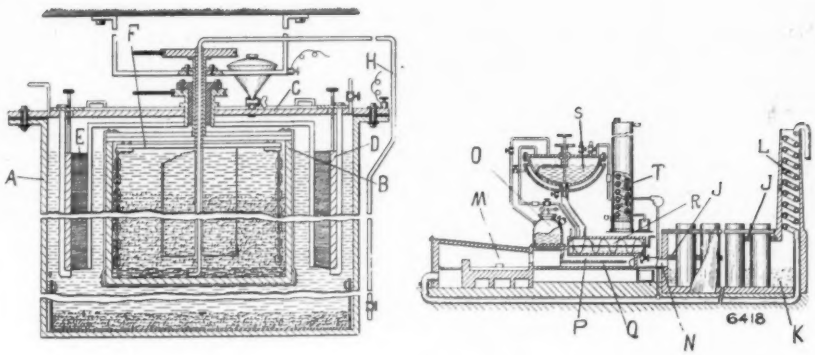
Thus the inventor claims that none of the substances entering into the reaction are used up except the coal and the oxygen of the air. The tin is recovered from the oxide by reduction with coal; mercuric oxide is regenerated from the metal by treatment with nitric acid, and the nitric acid is regenerated by oxidation with atmospheric oxygen.

In its simplest form the cell consists of an outer vessel *A* (Fig. 1) of nickel-plated iron or nickel-steel containing as positive electrodes the tin plates *D*, which are suspended from the cover *C* and are in metallic contact therewith, so as to make the metal cover part of the positive element. A porous carbon cup *B* suspended from the cover *C*, but insulated from it, forms the negative element. Mercuric oxide forms the depolariser, and an aqueous solution (2—1) of caustic potash, maintained at a temperature of 160 degs. Cent., the electrolyte. The tin of the tin electrodes is oxidised to stannous oxide, which deposits on the electrodes and is removed by brushes *E*, the stannous oxide dropping to the bottom of the cell, from which it is removed from time to time.

In order to prevent the depolariser from becoming exhausted, a stirrer *F* is provided within the carbon cup. The metallic mercury formed by the reduction of the depolariser is drawn from the carbon vessel *B* by means of a syphon *H*. The mercury recovered is dissolved in nitric acid, and the mercuric nitrate heated to convert it into fresh oxide as described, the acid vapours evolved being treated with air and steam to regenerate the nitric acid.

The stannous oxide, on removal from the cell, is reduced to metal in a flat-hearthed furnace by means of coal, and the surplus heat used for effecting all the reactions previously described.

Systematically arranged, the plant consists of from thirty to sixty cells, formed into a battery, placed in a chamber forming a part of the flue provided for the escape of the products of combustion from the stannous oxide reduction furnace (*J*, Fig. 2). The feet of the cells are sunk in a bed of sand, gravel, or mineral wool *K*, to keep the bottoms insulated. The heat residue remaining in the gases, after passing through



FIGS. 1 AND 2.—DETAILS OF JONES CELL AND GENERATOR.

the heating chamber, is utilised for heating the air contained in the coil *L* of the air-duct which feeds the furnace.

The products of combustion issuing from the reducing furnace *M* pass along the flue *N*, first raising steam in the boiler *O*, then through the flue spaces *P* and *Q*, heating a horizontal drum *R* containing the mercuric nitrate.

The mercury from the cells is forced into the reaction vessel *S*, where it is mixed with nitric acid, and heated by steam from the boiler shown, forming mercuric nitrate, which is discharged into the drum *R*, where it is broken up by heat, forming mercuric oxide. The latter is removed from the drum by a crank-driven conveyor.

The nitrous fumes evolved in the drum and pan pass into the condenser *T*, which is supplied with hot air by a fan, yielding nitric acid again, which is collected in a porcelain vessel.

The inventor states that the e.m.f. of each cell is 1·06 volts, and that the current strength of a cell holding 1·5 gal. of liquid is about 23 amps, with an external resistance of ·02 ohm.

He furthermore claims that the efficiency of the cell itself is 85 per cent., and of the whole apparatus of several hundred horse-power capacity 66 per cent., of the latent chemical energy of the coal. The latter figure Mr. Jone arrives at by the following process of reasoning:

The efficiency of the reduction of zinc compounds by means of coal is about 2·6 per cent.

As only one half of the energy of the zinc is obtained in the ordinary zinc cell, the latter represents only about 1·3 per cent. of the energy of coal consumed. In the reduction of stannous oxide, however, the energy of the carbon monoxide is utilised, carbon monoxide reducing stannous oxide, but not zinc oxide. The efficiency of the stannous oxide reduction is therefore increased from 2·8 per cent to about 10 per cent. and, furthermore, as this reduction takes place at a temperature but half as high as that of zinc reduction, the heat losses are reduced from 90 per cent. to 45 per cent., which increases the efficiency from 10 per cent. to 55 per cent. Again, as the reduction of freshly precipitated stannous oxide requires but half the time that it would require if it were a native ore, the waste is reduced from 45 per cent. to 23 per cent., or the efficiency is increased to about 77 per cent.

As additional evidence of the correctness of this reasoning, Mr. Jone states that when tin stone is used (impure stannic oxide) in place of finely divided stannous oxide, an efficiency of 25 per cent., as quoted in standard metallurgical text-books, is obtained in the reduction of the metal, which makes the efficiency of the battery 25 per cent. of 85 per cent. = 21·5 per cent. But as the reduction of the lower oxide of tin requires a temperature of but 500 degs. Cent., while the higher occurs at about 1,000 degs. Cent., the heat losses are again reduced by one-half. This would apparently represent the efficiency of the apparatus at about 53 per cent.

The battery has also been examined by Drs. Thurlemann and Beyenbach, Professors of Chemistry in the Monadnock School of Assaying, Chicago, the former of whom asserts that "the cell has an efficiency of 90 per cent., so that if 10 per cent. be

allowed for the oxidation of the depolariser, about 49·50 per cent. of the energy of the coal is obtained as electrical energy."

Dr. Bayenbach finds that the efficiency of the reduction of tin from the lower oxide as derived from Jone's battery will be 60 per cent. on a working scale, and that "3 lbs. of tin are required for each ·746 k.w.-hour This quantity of tin may be re-obtained by the expenditure of $\frac{1}{3}$ lb. of anthracite or $\frac{1}{2}$ lb. of bituminous coal."

The inventor concludes the description o. his apparatus by stating that he is able to substitute a cheaper metal for the mercury, which can be re-oxidised by atmospheric oxygen directly, so that the use of nitric acid is eliminated, and that his next step is to make a large battery. Whether this battery will fulfil all the claims made for it by its inventor remains to be seen, but it would appear that certain of Mr. Jone's figures relating to the losses of heat in the metallurgical processes are at least capable of revision, as according to C. J. Reed,* who refutes the conclusions reached by Jone, if to an ordinary zinc battery is adjoined a suitable furnace for regenerating the metal, as good if not better results can be obtained.

The other of the two recent attempts to provide an apparatus for the direct production of electrical energy from fuel differs from the preceding in that it is essentially a gas battery in which a hydro-carbon gas is oxidised. The oxidation takes place in an alkaline electrolyte between carbon and iron electrodes and sets up an e.m.f. of ·9 volts per cell. The temperature at which the oxidation takes place is much lower than that of a fire-box, being only about 392 degs. Fahr., hence the process takes place slowly. By gasification of the fuel minute subdivision is obtained, which is one of the chief features of the process.

The gas used may consist of ordinary illuminating gas, containing, say, 650 B.T.U. per cub. ft., diluted with about forty parts of air to one of gas to maintain an excess of oxygen. From a gas of such dilution it is obvious that producer or blast-furnace gases can be utilised, and even these must be diluted with air. The gaseous mixture is forced through the electrolyte under a slight pressure, that used at a demonstration of the apparatus given early in the year being about 4 lbs. per sq. in.

The electrolyte has for its chief ingredient caustic soda, to which is added a small quantity of iron oxide and a little calcium chloride to absorb moisture.

The construction of the cell, which is the invention of Mr. Jas. H. Reid, of Newark, New Jersey, may be made out with the aid of the accompanying diagrams, although the apparatus used in the demonstration differed in a few unimportant details from this.

The containing vessel is of iron (Fig. 3) and is divided into two parts, the upper *B* and the lower *A*, separated by insulation and forming the negative and positive *poles* respectively. The wire connections are shown at B^1 and A^1. From the upper portion *B*, are suspended the carbon electrodes *CC*, which are made in the form of hollow plates having porous walls through which the gas entering the holes in the top from the chamber *D* may filter and mix with the electrolyte. A top view of one of the plates is shown at *H* and a bottom view at *G*.

* *Electro-Chemical Industry*, New York, No. 1, Jan., 1904, pp. 18–23.

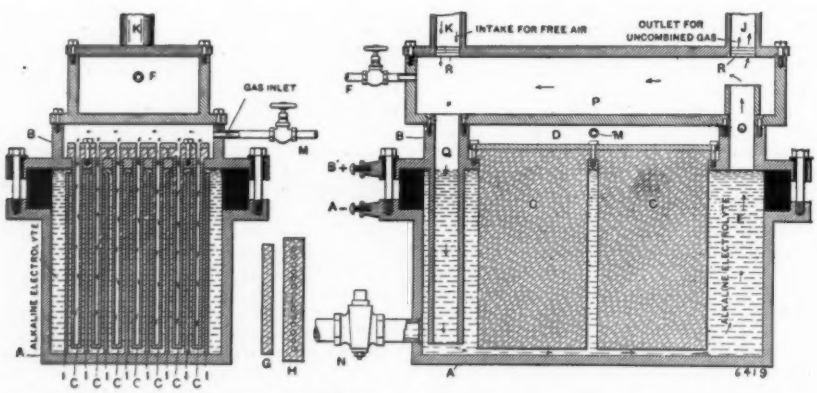


FIG. 3.—DETAILS OF REID'S CELL.

The lower portion *A* forms a trough containing the electrolyte, and from the base-plate project up the perforated iron plates *I, I*. Through the hollow carbons is forced the mixture of hydrocarbon gas and air, which percolates through the pores of the carbon, out into the electrolyte, passes up through this and escapes through the pipes *KJ*. By its passage through the electrolyte, the latter is caused to foam over into the chamber *P* above the cell, from which it runs back through the pipe *Q*. The electrolyte is thus kept constantly in circulation, and it is claimed that it is not affected by the reactions in the cell as it secures a fresh supply of oxygen in passing through the chamber *P*. Most of the oxygen necessary for combination is, however, supplied with the gas. The function of the iron oxide in the electrolyte is, explains the inventor, to serve as an oxygen carrier, in a manner analogous to the action of the red-blood corpuscles which carry the oxygen necessary to oxidise the carbon in the lungs.

The arrows indicate the direction of the flow of the electrolyte. The products of the oxidation and free gases which are combustible, escape through the pipe *J*, and in a commercial plant the inventor intends to utilise them

F indicates a pipe which gives admission to a jet of water for flushing the apparatus and also for admitting a small quantity at starting to replace that lost by evaporation from the electrolyte by the external heating which is necessary. The heating of the electrolyte is accomplished in the commercial apparatus, by utilising the heat radiated from the gas retorts, the arrangement being indicated in Fig. 4.

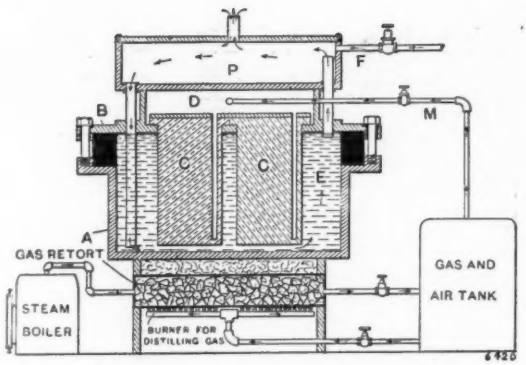


FIG. 4.—DETAILS OF REID'S CELL.

As before stated the e.m.f. of a single cell is about ·9 volt, and this perhaps is the chief practical objection that can be urged against the method, as it would require ten cells in series to obtain 9 volts. The ampèrage is proportional to the surface of the carbons, one ampère being generated for every 5 sq. ins. of surface.

The consumption of gas per e.h.p. is stated to be 5 cub. ft. of 650 B.T.U. per hour, and the commercial efficiency 45 per cent. of the total heat-units of the coal.

It is stated† that a company has been formed to exploit this apparatus, which is termed by the designer the "Dynelectron" and that there is in course of construction a 100-h.p. plant of ten cells, occupying a space of 8 ft. by 10 ft. by 8 ft. high to generate 7460 amps. at 10 volts.

† *Elec. World and Engr.*, Dec. 12, 1903.

The New Works of Messrs. Graham, Morton & Co., Ltd.

WE are reminded in the opening sentences of a souvenir booklet handed to us on the occasion of a recent visit made, in the company of over a hundred journalists and engineers, to the new works of Messrs. Graham, Morton & Co., Ltd., at Hunslet, near Leeds, that a considerable section of the press of this country have been engaged, *ad nauseam*, in reproaching British engineers with their backwardness in business methods and their antiquated workshops and plant, these plaints being generally accompanied by exhortations to adopt the "go-ahead" example of their more up-to-date American competitors.

There was a time when perhaps some justification could be found for much of this sort of criticism, but now that what may be termed the engineering *renaissance* is fully upon us, with the remodelling and re-equipping of works, a more extensive adoption of standardisation, electric driving, premium system, and what not, the time for girding at the British manufacturer has gone by.

It is a pleasure, therefore, for us to be able to chronicle a record achieved by a British firm, which, for smartness and enterprise, vies with anything ever achieved even in America. We refer to the complete construction and equipment of an extensive engineering establishment in the wonderfully short time of five and a half months.

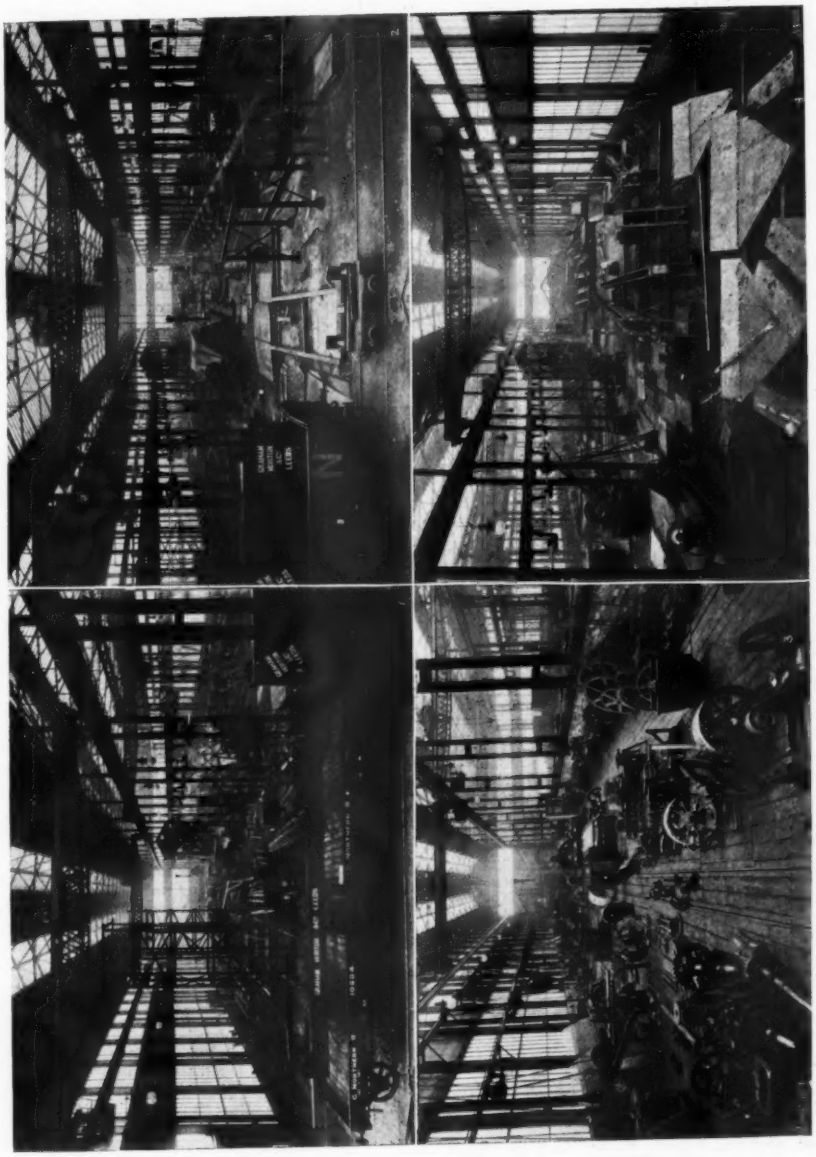
Messrs. Graham, Morton & Co., the firm we refer to, are well known as manufacturers of elevating and conveying machinery, crushing plants, inclined retorts, and as experts in constructional work, and originally carried on their business at Black Bull Street. Although the premises were spacious, they had to be three times extended, and the boundary line having been reached, first one branch establishment and then another had to be opened in different parts of the city. The inconvenience caused by this arrangement, and the heavy expense for handling plant and labour, led Mr. Maurice Graham, the managing director and founder of the firm, to look out for a suitable site where there would be room for future extensions, and where railway sidings could be carried into the works. Such a site was found at Pepper Road, but before entering upon the construction and equipment of the new works he crossed to the United States several times to investigate American methods and workshop practice, so satisfying himself that nothing should be wanting to enable the concern to adequately cope with American and German competition.

The whole of the building operations—excavations, brickwork, joinery, structural steel-work, plumbing, glazing, and slating—were undertaken by Messrs. Graham, Morton & Co., themselves, not a single part being let to a sub-contractor.

For this purpose a small but complete plant was erected, including stone-breakers, mortar-mill, cold saws, lathes, drilling machines, punching and shearing machines, wood planer, and circular saw. On May 16th, 1903, the first sod was turned on the site, and on November 2nd, 1903, the whole was complete, and as each man entered the works it was to find his place and work already assigned to him.

On entering the workshops one is surprised with the amount of light everywhere—in the whole of the large building there is not a single dark corner—the clearness of the atmosphere and the healthy conditions under which the men work. These find an explanation in the fact that the whole is constructed of structural steel and glass, a method which, in addition to bringing with it the above advantages, provides for the utilisation of a great deal of floor space which would otherwise be unavailable.

The building is 386 ft. in length, by 146 ft. in width, and covers an area of 5,985 sq. yds. It is formed in three bays, two of which are each of 52 ft. span, and the third of 39 ft. 9 ins. There are four rows of steel columns, which number about 120, and the roof principals number 99. The height from the floor level to the underside of the eaves of the roof is just over 39 ft., and the rise of the principals being 12 ft., the height to the apex is fully 51 ft., above which, on each of the three bays, is a ventilating louvre, running the whole length of the building, and which is 4 ft. high and 10 ft. wide. The sides and ends of the building consist of a dwarf brick-wall 5 ft. high, above which is 14 ft. of glazing. Then a row of corrugated-iron sheeting, on the top of which is another 9 ft. of glazing, the remaining portion being sheeted with corrugated iron. The whole of the roof of the centre bay is glazed, and on each side of the



THE NEW WORKS OF MESSRS. GRAHAM, MORTON AND CO., LTD.

(1) STEEL STRUCTURAL AND BRIDGE SHOP. (2) CENTRE BAY.
(3) FITTING SHOP. (4) PLATING SHOP.

two outside bays the roof is glazed for a width of 9 ft. the full extent of the building. About two-thirds of the ground space is occupied by the plating and erecting shops. At one end of the narrower bay there is an upper floor, which forms the chain department, the space below being utilised for stores and a tool-grinding room. The next 208 ft. of this bay forms the fitting shop, the remaining 58 ft. of space being occupied by hydraulic presses, the largest of which exerts a pressure of over 250 tons, and the plate-heating furnaces.

A particular feature of interest connected with the smith's shop consists in the exhaustion of sulphur, by which the air is kept free from sulphur fumes and rendered wholesome, a condition of things greatly appreciated by the men travelling with the overhead cranes.

Excess of air supplied by the fan for the blast is free to enter the 18-in. exhauster pipe, which commences at the fire farthest from the fan, extends the whole length of the fires, and passes out to the side of the building, where is placed an exhauster. The pipe is tapped at intervals to form an inlet to the hoods over the fires.

The works are electrically driven, and the machines, which are of the most modern description, are grouped and arranged so as to save expense and labour in handling material. At the end of the narrow bay stand the engine and boiler houses, the coal being brought into the latter direct from the railway trucks by means of an elevator and push-plate conveyor.

The boiler, of the Lancashire type, is by Clayton, Son & Co., Leeds, to which is applied a McPhail and Simpson superheater, and a feed-water heater by the Wheeler Condenser Co. The driving and lighting plant consists of two vertical 250-h.p. compound engines, by Bellis & Morcom, direct-coupled to E.C.C. generators, giving power to twelve motors, supplied by the Phœnix Dynamo Co., Ltd.; while a small 35-k.w. auxiliary set has been put down for lighting the offices when the works are closed. The power-house also contains a double-acting hydraulic pump for working the presses, riveters, and the capstans, which are used for hauling the trucks in and out of the sidings.

There are two lines of rails into the works, and overhead run three 10-ton travelling cranes.

Amongst the work going on were noticeable several portable conveyors (Markham's patent) for use on a tube railway, hot coke and band conveyors, all of which were in motion under trial. Under construction were also a number of bridges for the Great Western Railway and Indian State Railways, a steel structure for the Harrismith Electric Power Station, coal and ash handling plants for electric power stations in London, and 500-ton coal bunkers for Melbourne.

The pattern shop and stores occupy a separate structure, 60 ft. by 24 ft., which was erected and occupied within a fortnight.

The offices, which form a prominent feature from Pepper Road, are constructed of best Accrington brickwork, and are 270 ft. long by 42 ft. wide. They are extensive, and it may be added that they are light, lofty, and comfortable, and well adapted for the purposes for which they were specially planned. The drawing office is 107 ft. by 42 ft. wide, and is a magnificent apartment, accommodating 50 draughtsmen.

The quantity of glass used, given in square feet, was 61,550; the iron-work amounting to 3 3 tons of steel joists, 323 tons of sectional steel, and 50 tons of bolts. As many as 500 workmen were at one time employed on the site, whose operations were so arranged that as soon as one stage of the work was completed everything for the next was ready to be immediately placed in position.

The conduct of the whole of the work, in fact, forms an admirable object-lesson in what may be accomplished by specialisation and organisation, and Messrs. Graham, Morton & Co., are to be congratulated not only upon the manner in which they have added to an already high reputation, but that their achievement has won the commendation of H.R.H. The Prince of Wales, who, as is well known, is keenly interested in all that relates to the welfare of British industry.

The following is a copy of the letter received by Mr. Maurice Graham :—

"Marlborough House,
"*29th March*, 1904.

"SIR,—The Prince of Wales desires me to thank you for the copy of the souvenir illustrating what has been done by your firm in the design and construction of new engineering works, built on the most modern and up-to-date principles, which you have been good enough to send for His Royal Highness' acceptance. His Royal Highness has read your letter of the 28th inst., and desires me to congratulate you in his name on the great rapidity with which your undertaking was carried out.

"I am, Sir,
"Your obedient Servant,
"ARTHUR BIGGE.

"Maurice Graham, Esq.,
"Pepper Road, Hunslet,
"Leeds."

BOOK NOTICES.

An Elementary Treatise on Hoisting Machinery, including the Elements of Crane Construction and Descriptions of the Various Types of Cranes in use.—By Joseph Horner, A.M.I.Mech.E. (London: Crosby, Lockwood & Sons, 1903.) Price 7*s.* 6*d.* net.

Although termed by the author a treatise, this book may be more correctly described as a detailed description of various types of cranes made in the present day. In Section I. are reviewed the elements of crane construction, such as frames, jibs, posts, cheeks, stretchers, bases, gears and accessories. The details here given refer to practically all varieties of cranes, and the letterpress is illustrated by numerous diagrams. All this matter is interesting, and should be of service to mechanical engineers and draughtsmen. Readers of this class, however, will probably regret that the theoretical part of the subject has been entirely omitted by the author, who seems to think that what he calls the "shop method" of treatment—with which he is more especially familiar—is all that is necessary in the present volume. Section II. constitutes a brief summary of the methods available for the operation of cranes, and Section III. deals briefly with the materials used in crane construction. In Section IV. we have a comprehensive classification of various types of cranes, Division I. being devoted to hand cranes of different kinds, and Division II to power cranes. This last section will probably be appreciated by intending purchasers and users. The whole of the descriptive matter is clearly expressed, and, on the whole, well arranged. The volume is excellently produced, and is illustrated throughout with detailed drawings, while in the last section there are several interesting photographic views of modern hoists and cranes.

Canada in the Twentieth Century. By A. G. Bradley. (Archibald Constable & Co., Ltd., Westminster, 1903.) Price 16*s.* net.

In this volume we have an exceedingly interesting picture of Canada and Canadian life in readable form. The whole of the book should appeal to our readers, all of whom we assume to be interested in the past history and present development of the Dominion. But in addition to giving merely descriptive accounts of the country and its people, the author has added much information which will be both useful and instructive to engineers and manufacturers. The reader will also find full information relative to the prospects of settlers in the different provinces, each possessing its own characteristics and conditions of industrial life. Although not a technical publication, we have great pleasure in recommending this book to the perusal of our readers, and we may add that its value is very much enhanced by the large number of photographic views accompanying every chapter.

Designing Ironwork. — By Henry Adams, M.Inst.C.E., M.I.Mech.E., F.S.I., Professor of Engineering at the City of London College. (Published by the Author at 60, Queen Victoria Street, E.C., 1903.) Price 2*s.*

In this pamphlet we have the fourth part of a work which we believe will be published hereafter as a text-book on the design of constructional ironwork. The present instalment contains data relative to rolled steel joists, compound girders, concrete and fire-resisting materials, followed by calculations and working drawings for a fire-proof floor. It will be seen, therefore, that the title scarcely covers the whole of the subjects treated, but the pamphlet certainly contains a most useful collection of practical notes which should be of service to engineers as well as to students.

Slide Valves.—By William Dyson Wansbrough. (The Technical Publishing Co., Manchester, 1903.) Price 4*s.* 6*d.* net.

In this book we find a collection of practical notes which originally appeared in *The Mechanical World.* The author devotes a preliminary chapter to the geometry of the slide-valve, making clear three important points which it is desirable should be thoroughly understood before constructional diagrams are studied. The six chapters which follow deal fully with different problems connected with slide-valves, and contain internal evidence showing that the writer thoroughly understands his subject. It is very unfortunate, however, that the arrangement of the book and proper heading of the chapters should have received so little attention. There is no index—a detail which is generally thought desirable in the present day; in two of the chapters the title has been omitted, and in the case of others the titles or the chapter numbers do not agree with those stated in the Table of Contents. These defects militate very much against the usefulness of the book, which is certainly most inconvenient for purposes of reference in its present form.

WORKS MANAGEMENT AND WORKSHOP PRACTICE.

Conducted by JOHN ASHFORD, M.I.Mech.E., and W. H. WILSON.

Increasing Profits.

By John Ashford.

In an establishment where the result of the year's working has not proved satisfactory, the broad question has to be faced: How can profits be increased? This is a question more easily asked than answered, because there are so many factors that contribute to the result, yet it is of such general interest that a little time spent on its consideration will not be wasted. In this section of THE ENGINEERING REVIEW we are more particularly interested in matters directly concerning the workshop, as distinct from the commercial side, therefore we will consider the question from the practical point of view.

Profit is a word that scarcely needs defining, yet if it is preceded by either of the words gross or nett, we find a little explanation necessary. The nett profit, we may take it, is the amount of the selling price that is left after deducting the costs of production, plus the cost of selling, together with all other charges against the business. The gross profit is variously understood, but more generally it is used to indicate the difference between the selling price and the cost of production; it is therefore subject to the costs of selling and general charges before it becomes a nett profit. Suppose we then consider that to obtain nett profit three main divisions of charges must be deducted from the selling price, *i.e.* cost of production, cost of selling, and general charges; so, to increase the margin of profit, one or more of these items must be reduced. The charges are considered in this way with the assumption that the establishment is broadly divided into two main departments, the producing and the selling, the costs of each being readily divisible so that they can be examined independently of each other.

That the balance-sheet may be healthy, it is essential that the cost of production should constantly be watched; and, accepting the general idea that progress is continually taking place in the engineering world, the tendency of the cost should be constantly downward. The safe assumption is that rival firms are successful in their efforts to do this, and unless you do likewise you stand to be left behind; therefore, the constant thought and effort of the works management should be directed to this all-important matter. Immediately those responsible for the management of the works think they have reduced costs to their *lowest* possible level, they should be "outed," whatever profit the firm may be making, for it implies stagnation and the certain consequences will follow all too soon. It is folly to wait for an adverse balance-sheet before taking action.

Costs of production may, for convenience, be divided into three heads:—(*a*) Material; (*b*) Labour chargeable to known work; (*c*) Manufacturing charges, including general and non-producing labour.

In a manufacturing engineer's establishment these charges will approximately each equal one-third of the total cost of production, but, of course, will differ according to the nature of the product, etc.

The cost of material will be determined by the market, so cannot be reduced, except by carefully watching the designs of the machinery manufactured to avoid excessive weight. In this way, much can often be done by skilful designing to keep down the cost of material, and smart draughtsmen who continually attend to this are worth keeping at good money.

Turning to item (*b*) of the costs of production, labour is usually paid for by the hour or by the piece. To decrease the wages-cost when paying by the hour, either the rate per hour must be reduced, or the amount of work done in the time must be increased. To decrease the rate per hour would be fairly

certain to lead to labour troubles, and for the purposes of this discussion may be immediately put aside as not feasible ; therefore, the only alternative is to take steps to increase the rate of production. It is not to be expected that this increase will be obtained except by one of two methods ; namely, either by offering some form of inducement to, or by putting pressure upon the men. The only form of practicable inducement is a reward, and that must be in money ; consequently, inducement must be considered under the head of piece-work or premium. There is, then, only one thing left as a means of increasing output when working day-work, and that is by increased supervision ; or, to put it in another way, to place the operatives under such close observation that they cannot skulk or ease off in their work without their foreman being aware of it ; and he must constantly urge them forward, even to the extent of dismissing the laggards.

We might ask the question : How many men can a foreman effectually supervise ? The writer has known instances where a foreman has been expected to control about a hundred hands, attending to all piece-work matters, distribution of work, and the passing of same when finished, etc., without any assistance whatsoever, and under such circumstances a low rate of production must result. To obtain anything like a high rate of production of reasonably good quality, a foreman should not have more than from 25 to 30 hands to control, for it is practically found that the rate of production will steadily decrease in about direct proportion to the increase in the number of hands under his control beyond 30. This remark applies not only to work done by the hour, but also in large measure when work is done by the piece, for the mere fixing of a piece-work price is by no means a guarantee that the work will be done in a satisfactory time.

Piece-work.

Turning to piece-work, the first question is : Are the prices satisfactory considering the methods and the means at the disposal of the workman ? The author, before answering this question, would first enquire how the prices had been fixed. When the prices are fixed by the foreman it is often done in the following manner : The work is given out to be done by day-work, and the time taken is noted, the foreman presumably watching the job to see that it is done in fair time, and with this foundation as a guide the price is settled. According to the stamp of man the foreman may be, so the price will vary. It is but to be expected that the men, knowing the usual custom of the shop, act accordingly, and that, knowing the day-work time will be taken as a basis, will hold back the job to get the highest possible price. The general result of such a method as this is that prices are certainly higher than they might be, without any disadvantage to the men.

There is a general unwritten rule that when working piece-work the men should be able to earn a balance up to 25 per cent. of their standing wages, and that when they exceed that amount the price should be re-adjusted. The practical result that this brings about is that the men not only do not, but will not, exceed the 25-per-cent. balance on the average, more usually limiting it to about 20 per cent., with the consequence that when the prices are fixed too high the work is simply kept about the shop a correspondingly longer period. When a job goes through for the first time, it is not to be expected that the best methods and means of doing it will be obtained ; thus, the double effect, namely, holding back and lack of best methods, will probably mean that the piece-work price so set will be from 20 to 50 per cent. higher than there is need for it to be. There is no intention here to suggest deliberate dishonesty on the part of men, but to indicate the natural result of a faulty method. Of course, where better means of fixing piece-work prices are in vogue these remarks would not apply with the same force.

The adjusting of existing piece-work prices is invariably accompanied by discussions and disputes with the men, and if not carried out with great discretion will have a reverse effect to what is intended, consequent upon creating a bad spirit in the shop. Adjustments in a wholesale manner, such as a 5-per-cent. reduction all round, would cause more disturbance than the selection of obviously high-priced jobs and lowering them a much larger amount, for the men naturally select the finely cut prices for discussion among themselves. It is a good rule to take that no price shall be reduced unless it can be shown that the new price will admit of the work being done in a time that will allow the man to earn a fair balance.

Discussions arising from the adjustment of piece-work prices are very apt to cause bad feeling, making the men dissatisfied ; and when such is the case it is sometimes the wisest course to take a bold step and depart from the existing system in the shop entirely, branching out, say, into the premium system. In this way it is more easy to shake off the legacy of the past, and start out with a clean slate. Thus, by systematically and carefully fixing the times for the work on the new system, satisfactory results to all parties

may be obtained. If properly operated, the premium system may be used as a means to obtain the best efforts from the men, so securing a reduction in prime costs without penalising them ; they, on the contrary, often being able to earn higher balances than they had hitherto done by piece-work. This is so, for the system, when rightly operated, becomes a profit-sharing—or, perhaps, more correctly speaking, a reduced-costs sharing—system. When the man shares in the reductions effected, and has no fear of future cutting of prices, the necessary inducement is placed before him to put his best efforts into the work.

The writer has, by the aid of the premium system, actually obtained reductions in wages-cost, as compared with piece-work prices, up to even 50 per cent. ; the men at the same time getting balances highly satisfactory to themselves, amounting to from 30 to 50 per cent. of their wages.

When setting out to reduce prime costs it must not be expected that reductions will be effected without outlay of some description, for it is not in the natural order of things that you should get anything for nothing ; consequently the point to watch is not that expenditure should be avoided altogether, but that the returns are sufficiently in excess of the outlay to leave a solid resultant.

Machine Cost.

Another very important section of the cost of production is what we might call the machine cost, that is to say, the cost of running the machine while doing the work under consideration. A machine should be considered to have certain charges put against it ; not only the interest upon the capital it represents and its depreciation, but also a share of the rent, rates and taxes, depreciation of buildings, power, light, insurance, and works-management charges. Before the machine earns a profit, it must produce sufficient work to cover its proportion of these expenses. It is, perhaps, convenient to charge these latter to the various machines according to the floor space occupied. Considered in this way, it will be found that very few machines cost less than an amount equal to the operator's wages. Looking at it in this way it will be seen that the time that a piece of work is on a machine is all-important, for its cost is not merely the operator's wages, but a further amount, at least as much again, and frequently considerably more. Stress is placed upon this because work is frequently given to an apprentice or improver at the same prices or but little less than those given to a mechanic, with the result that the work is kept on the machine a much longer period, and while seemingly costing less it is actually costing considerably more than if done by a highly-paid man. Recognising this fact, it is sometimes an advantage to force the work through the machines in a shorter time, even without reducing the piece-work price, by raising the man's weekly wage, and requiring him to still make his full percentage of balance or clear out.

The above remarks also go to show that it is not wise to cut down unskilled labour assistance too much, or the machines may be kept waiting longer than they should do when changing jobs ; and they also go to show that smart, quick means of handling work into and out of the machines is an important factor in economy. Again, a poor quality tool-steel may entail a machine running slowly, whereas even 5*s*. per lb. for steel would be cheap if it added 10 per cent. to the output from the machine.

Fitting and Erecting Cost.

Turning now to fitting and erecting to look for means of reducing costs on that side, the more nearly this work can approach to a mere process of assembling the cheaper it will become. To reduce these costs, the aim must be to supply the men with work that has been machined to a very close degree of accuracy. Moreover, when an erector starts to assemble an engine or machine, there should be absolutely no waiting for work, for every minute spent in waiting or looking for work spells loss.

The consideration now becomes, How can we insure that the fitters shall, in the first instance, be supplied with accurately machined work? This can only be done by having the work systematically inspected before it reaches them, and if this is to be properly done it must not be left to foremen, but it must be examined by competent inspectors, who shall have been instructed as to the degree of accuracy to be enforced. For the inspectors' work to be thoroughly effective, it is necessary that they should be required to put their mark upon all piece-work contracts, to certify that the work has been examined and is of the required standard, before the contract is passed for payment. This entails inspection after every operation, and it has the additional advantage that waste work is discovered and thrown out before further money is spent upon it. Very effective pressure may in this way be brought to bear upon the men to force them to maintain the quality required. Putting this in another way, inspection of work is instituted to ensure the getting of adequate return as to quality and quantity for money spent.

Here, again, it should be noted that to secure the high quality necessary to be

effective in reducing erecting and fitting costs, some outlay is necessary in the form of wages to inspectors, yet, if the whole is well balanced, the saving will more than justify the outlay.

A very fruitful source of loss is in the time spent by skilled mechanics in hunting around for work. The writer has seen this in a most aggravated form, for he has seen machines standing idle while the operator has been away at the foundry or smithy looking for his rough material; he has seen fitters hunting around machines for the details they require to complete the work they are fitting; and he has seen erectors spending their time in the fitting department enquiring for the parts to make up their engines. Mechanics' wages are not paid for such as this, but for skilled work, and other provision should be made for bringing forward the work through the shops, so that the mechanics' whole attention may be concentrated on the work before them.

It is in providing the proper means for progressing the work and eliminating such unnecessary losses as those mentioned, that the true organiser shows his value.

To obviate this wastage, stores should be provided for rough material and for finished parts, and those in charge thereof, together with the inspecting staff, should constitute the mechanism for progressing the work through its various operations until it reaches the finished-work stores. If fitters and erectors are required to look to the stores only for their work, and the storekeepers are required to gather together the work so that it may be ready for them, the otherwise wasted time of skilled mechanics will be saved.

The Supply of Small Tools.

Another most important matter affecting the cost of production is the provision of a satisfactory supply of small tools for the machines. That machine-tools may produce high-class work at low cost, they must be both properly tooled and themselves kept in good condition. Lacking these two essentials, time must unavoidably be spent in correcting the errors of the machine, or in "tinkering up" or "nursing" poor tools, and the time so spent is doubly costly, because it means the loss of both the time of the mechanic and of the machine. A properly operated tool department that is responsible for the production of new tools, the maintenance of those in use, and the keeping of machine-tools and the general plant in satisfactory working condition, is a most valuable assistant in reducing costs of production and holding them within required limits.

It is very remarkable that all too frequently managing boards quite fail to realise the importance of these several means of reducing prime costs, and will quibble at the outlay necessary to set such methods into operation, in spite of the fact that the expenditure if under good control will bring back most excellent returns.

Many establishments there are which at one time paid good dividends, and still have good business connections, which not only fail to earn adequate returns upon their capital, but gradually drift towards that undesirable finish — voluntary liquidation, bankruptcy, or absorption, to the accompanying dirge of bad trade and keen competition, when the real fault lies in themselves.

The right policy, to steer clear of such an undesirable future, is to thoroughly organise the establishment, to systematically maintain the producing-plant in a high state of efficiency by constant repair and the addition of the latest machinery, to improve the design and quality of the product, and to see that prime costs not only keep to their proper level but are continually reduced. If such a policy is backed with sound financing and commercial management, the future can be faced with confidence.

Some New Tools.

THE variation of speeds inseparable in milling-machine operations have somewhat retarded the application of direct motor driving. This problem has apparently been satisfactorily solved by the advent of two machines of recent construction, one English and the other American. The first named is by Messrs. Archdale & Co., of Birmingham, and represents a plain miller driven by a 2-horse-power motor of the Lundell type, which is fixed on a bracket cast on the left hand of the machine body, and shown in front elevation at Fig. 1. The gears, which are all machine-cut, are protected by a casing, on the right-hand side of which are placed the levers for bringing the several gears into mesh. The spindle, which is large in diameter, runs in parallel bearings of hard gun-metal. The face of the table has planed T-slots for setting the work, and part of the equipment is a swivel vice having a maximum opening of 4½ inches. The variations of speed, to the number of 66, are made through the combinations of a regulating starting switch, double gearing and variable gear. The table, which is 2 ft. 6 ins. long by 11½ ins. wide, has a longitudinal, transverse and vertical movement of 6 ins., 18 ins. and

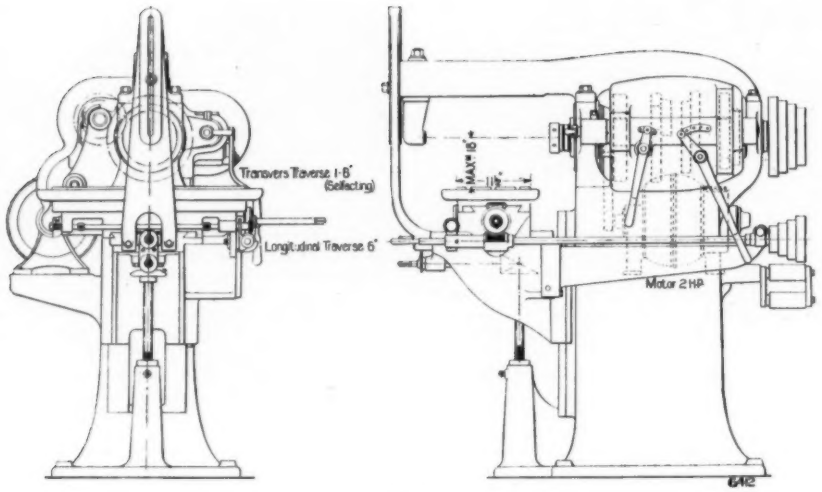


FIG. 1.

11 ins. respectively. The transverse movement is self-acting with four changes of feed, these being effected by a belt drive on cone pulleys from the spindle to the worm shaft. The vertical movement is by handle, engaging mitre wheels and screw. The cutter mandril during a heavy cut is supported by a movable centre carried on the overhead arm. Any tendency of the latter to spring is entirely eliminated by a slotted support fixed on the front of the table, and which can be tightened against the extreme end of the arm. The regulating switch is fixed on a movable standard, which can be placed in any convenient position, as shown on the right of Fig. 2. The design of the machine, we think, is rather marred by the type of overhanging arm; and a decided improvement could be made by widening the base, which we think too narrow for the upper part of the machine and the weight of the superimposed motor.

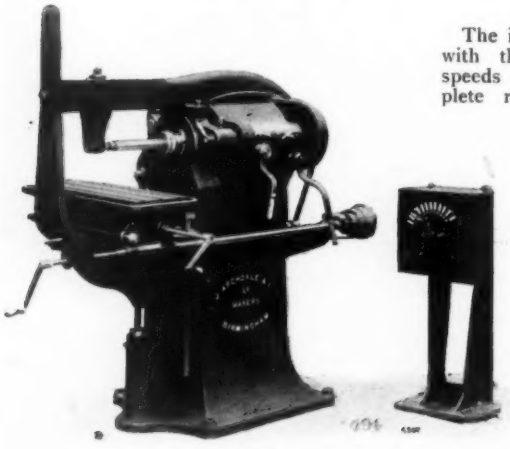


FIG. 2.

The introduction of the high-speed steels with the greatly accelerated feeds and speeds has been overcome by the complete revision of the lathe and other tools where the revolutions are limited to one direction. In the planing machine, however, this has presented some difficulty, consequent upon the reversing of the table at an abnormally high speed. To obviate the stress, what is termed a cushioning device has been recently patented by Messrs. Smith & Coventry for use on their planing machines. It consists of an interlocking clutch provided with helical jaws, which form sliding surfaces that are claimed to resist the shock consequent upon the reversal of a planer table. The amount of movement or

slip of the jaws is controlled by the pressure of a powerful helical spring inserted between a threaded collar and the back of the clutch, as shown on the left of illustration (Fig. 3). In this device it is claimed that the energy created by the momentum of the table on the cutting stroke is stored in the powerful spring, which adds impetus to the gearing on the opposite stroke. The clutch is shown in detail at Fig. 4, and some idea may be formed of the power of the spring when it is stated that in the smaller machine to which it is attached the table can be started without the assistance of the belt. A similar arrangement has also been recently tried in connection with a heavy chain-wheel drive. This special form of drive was applied to some very heavy three-throw cranks working the pumps at the Salford Electrical Station. The rim of the wheel is independent of the centre plate, which is a separate casting keyed on the shaft. Four external projections on the latter are machined to fit a corresponding number of internal ones on the rim. The two main parts are kept in lateral position by a disc on each side, which also forms a shroud and prevents any possible side-slip of the chain. Strong helical springs, inserted between the projections, take up the vibration and intermittent shock, thus minimising the wear and the tendency to stretch the chain consequent upon sudden starting.

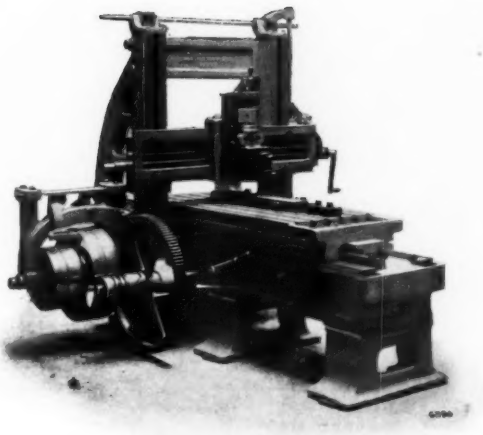


FIG. 3.

We recently recorded the details of a very powerful 14-in. constant-speed geared lathe built by Messrs. J. Hetherington & Sons, Manchester. And now we call our readers' attention to a much heavier type of machine-tool. We refer to the 24-in. high-speed lathe by the Tangye Tool & Electric Co., of Birmingham, as illustrated at Fig. 5. This massive machine, which was only completed a short time ago, is one of the most representative pieces that has been issued by this firm. The enormous head-stocks are mounted on a massive bed 35 ft. long, 42 ins. across the slides, 23 ins. deep, and with a capacity between centres of 24 ft. The fast headstock carries a forged steel spindle, 12 ins. diameter, and having a front bearing 15 ins. long; its equipment of gearing with a purchase of 128 to 1 being driven by a 10-inch belt running on a 27-inch diameter double-flanged pulley. The motion of this pulley is derived from a variable-speed countershaft directly driven from the main shafting. By this arrangement the spindle can be driven from single, double, treble, or quadruple gear, which gives a variation in speed from 100 revolutions down to 1½ revolution per minute. The guide-screw is so arranged that it can be brought into use when necessary for screw-cutting purposes, the sliding and surfacing motions being obtained from a separate shaft. This is a very good feature,

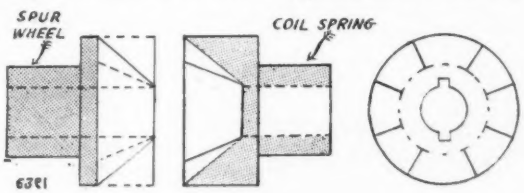


FIG. 4.

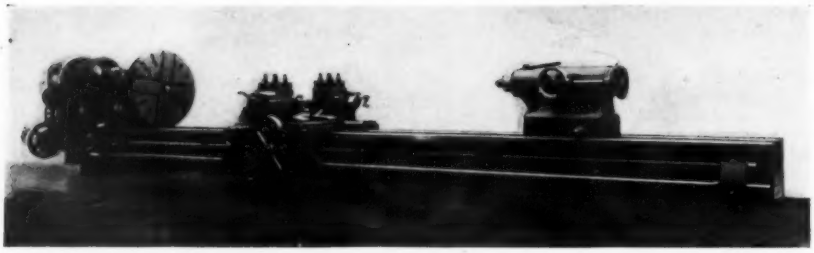


FIG. 5.

as it would involve considerable wear if the screw were requisitioned for sliding as well as screw-cutting. This shaft has six feeds, viz., 4, 6½, 10, 16, 26, and 40 revolutions per inch of feed, and these are changed by the mechanism operated by lever shown at front of fast headstock in Fig. 2. Two powerful compound slide-rests are mounted on the saddle, with tool-holders so arranged that two or three tools may be operating simultaneously. The whole of the feed-motions on the saddle are thrown in or disengaged very rapidly by friction cones. It is specially made to use high-speed steels, the same being employed in the appended tests, which were conducted *not* under the most favourable circumstances, as the lathe was resting on wooden foundations, a temporary drive being effected by a portable motor. The trials were conducted for the first seven tests on a forged-steel (·25 per cent. carbon) shaft, 17⅝ ins. diameter, the last test being made on a wrought-iron shaft 11½ ins. diameter. During the trials from 60 to 70 b.h.p. was consumed, the lathe removing about 1 ton of cuttings per hour, and taking in some instances a cut 1 in. deep with a ¼-in. traverse without any difficulty. The loose headstock is provided with a steel spindle 8 ins. diameter, and is arranged with saddle for taper sliding. It is moved along the bed by means of a worm wheel and rack, which enables it to be securely locked in position, and effectually prevents the tendency to back

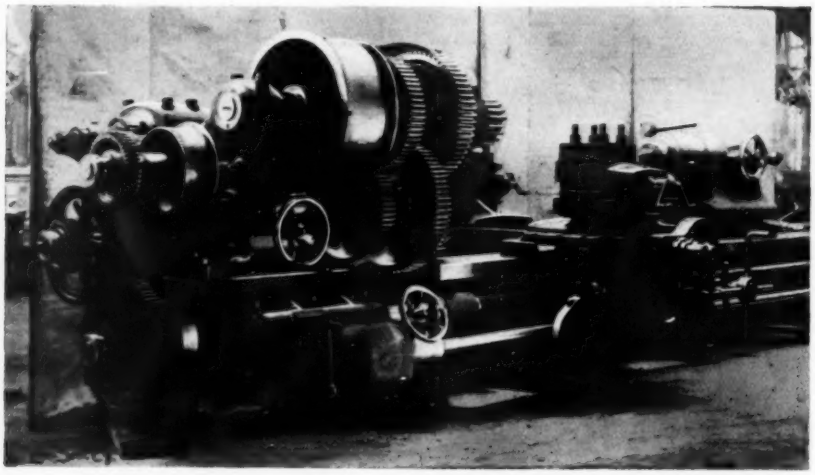


FIG. 6.

movement which is often apparent when taking heavy cuts. The whole of the machine is of colossal proportions, and is a distinct departure from all ordinary design, yet all the movements are easily manipulated. From the submitted tests it has undoubtedly achieved remarkable results, and all that could have been anticipated.

24-INCH HIGH-SPEED LATHE TESTS.

TEST.	Depth of Cut.	Feed per Rev. of Work.	Cutting-speed in ft. per min.
	Ins.	Ins.	
A	1	$\frac{1}{4}$	32
B	$\frac{13}{16}$	$\frac{1}{4}$	32
C	$\frac{3}{4}$	$\frac{1}{4}$	32
D	$\frac{9}{16}$	$\frac{1}{4}$	32
E	1	$\frac{1}{16}$	80
F	$\frac{3}{4}$	$\frac{1}{4}$	80
G	$\frac{9}{16}$	$\frac{1}{4}$	80
H	$\frac{7}{8}$	$\frac{1}{4}$	50

BOOKS.

Microscopic Analysis of Metals. By Floris Osmond, C.E. Paris: edited by J. E. Stead, F.R.S., F.I.C. London: Charles Griffin & Co., Ltd., Exeter Street, Strand. Price 7*s.* 6*d.* net.

Electric Traction. A Practical Handbook on the the Application of Electricity as a Locomotive Power. By John Hall Rider, M.I.C.E., M.C.I.E.E., etc. London: Whittaker & Co., 2, White Hart Street, Paternoster Square, E.C. Price 10*s.* 6*d.* net.

Steam Boilers. Their Theory and Design. By H. de B. Parsons, B.S., M.E., etc. London: Longmans, Green & Co., 39, Paternoster Row, E.C. Price 10*s.* 6*d.* net.

Entropy; or, Thermodynamics from an Engineer's Standpoint, and the Reversibility of Thermodynamics. By James Swinburne. London: Archibald Constable & Co., Ltd., 2, Whitehall Gardens. Price 4*s.* 6*d.* net.

Refuse Disposal and Power Production. By W. Francis Goodrich, A.I.Mech.E., etc. London: Archibald Constable & Co., Ltd., 2, Whitehall Gardens. Price 16*s.* net.

Modern Electric Practice, Vol. II. Edited by Magnus Maclean, M.A., D.Sc. London: Gresham Publishing Co., 34, Southampton Street, Strand. Price 9*s.* net.

English and American Steam Carriages and Traction Engines. By William Fletcher, M.I.Mech.E. London: Longmans, Green & Co., 39, Paternoster Row, E.C. Price 15*s.* net.

Specification for Architects, Surveyors, and Engineers when Specifying, 7th Annual Vol., 1904. Published by the Proprietors of *The Builders' Journal and Architectural Review*, Great New Street, London. Price 2*s.* 6*d.* net.

Logarithms for Beginners. By Charles N. Pickworth. London: Whittaker & Co., 2, White Hart Street, Paternoster Square, E.C. Price 1*s.*

Motor Pocket Book. By Mervyn O'Gorman, M.I.E.E., Assoc.M.I.M.E. Westminster: Archibald Constable & Co., Ltd., 2, Whitehall Gardens. Price 7*s.* 6*d.* net.

Traité Théorique et Pratique des Moteurs à Gaz et à Pétrole, T. II. By Aimé Witz. Edited by E. Bernard. Paris: 29, Quai des Grands-Augustins. Price 30*frs.*

Die Metalle Geschichte, Vorkommen, und Gewennung. By Dr. Phil Bernhard Neumann. Halle: A. S. Verlag von Wilhelm Knapp. Price 16*m.*

X-Rays. Simply explained. A handbook on the Theory and Practice of Radiography by R. P. Howgrave-Graham, A.I.E.E. London: Percival Marshall & Co., 26–29, Poppin's Court, Fleet Street, E.C. Price 6*d.*

Simple Experiments in Static Electricity. By Percival G. Bull, M.A., Oxon. London: Percival Marshall & Co., 26–29, Poppin's Court, Fleet Street, E.C. Price 6*d.*

Practical Shipbuilding. A Treatise on the Structural Design and Building of Modern Steel Vessels. By A. Campbell Holms, M.I.N.A. London: Longmans, Green & Co., 39, Paternoster Row, E.C. In two volumes, price £2 8*s.* net.

ENGINEERING ABSTRACTS

For List of Publications regularly reviewed see previous issue pp. 351–352.

MATERIALS AND MEASUREMENTS.

A Chart for Calculating the Strength of Shafts and Pins.

THIS chart is intended to simplify the work of calculating strength of solid shafts and pins subjected to transverse bending torsion, or shear. It is presumed that the reader knows how to calculate the bending moment and shear when the applied force and length of the shaft are known. When this has been done in the ordinary way the chart comes into use, and by the aid of the curves on the diagram, if any two of the three quantities—bending moment, shear, and shaft or pin diameter—are known, the remaining one can be read off on the upper half of the chart at the point of intersection of the line representing the two known quantities. When a shaft is subject to both torsion and bending moment, the lower half of the chart is similarly used.—**G. S. Walker,** *Amer. Mach., Vol. XXVI, No. 48*, pp. 1649–1651.

Lateral Earth Pressures.

WHILE theories concerning the action of granular masses as to planes of rupture and of friction, and as to lateral pressures, etc., are fairly numerous, they are not at all concordant with the results they produce; and these results are not in accordance with the few experiments made public, or with common engineering practice in the design of structures having to do with such granular substances. The author hopes that the experiments described in this paper will throw some light upon the subject, aid designers in getting nearer to the requirements in actual cases, serve to correct some errors in the several theories, and form a nucleus around which to build practicable working rules or, perhaps, a theory which will indeed agree with fact. The author first deals briefly with the work of other observers, and then describes his own experiments with a model retaining-wall and a testing machine. He concludes with a statement of various facts or conclusions, first deduced from his investigation, or brought out in confirmation of what experience has already taught.—**E. P. Goodrich, Jun.,** *Proc. Am. Soc. C. E., Vol. XXX, No. 3*, pp. 239–271.

The Preservation of Wood from Fire and Decay.

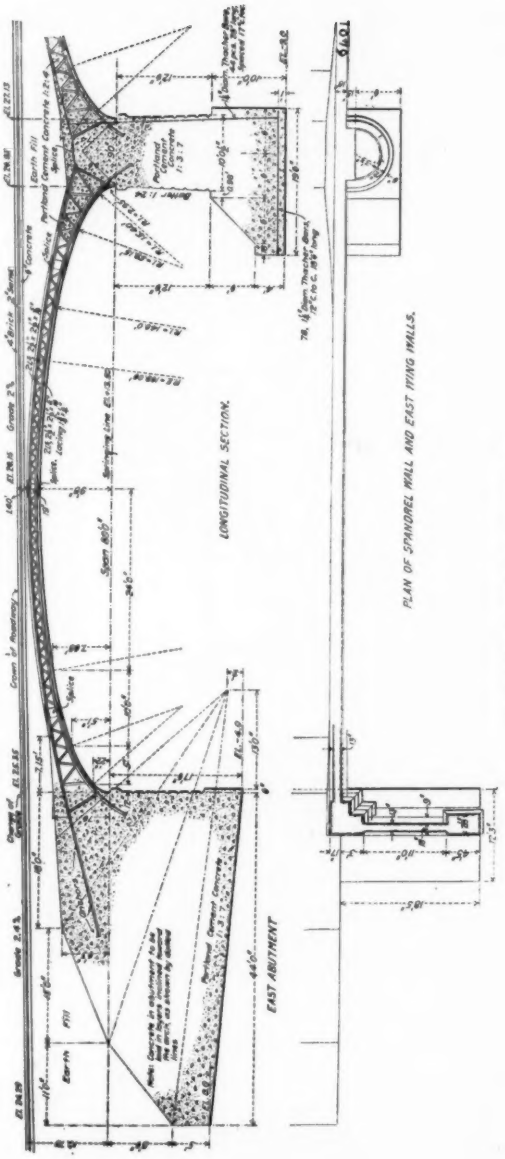
FOR the system developed by the author, the following practical results are claimed:—(1) The elimination of the property of inflammability from wood and other fibrous substances by impregnation with a permanent non-combustible chemical. (2) The practical plating of wood surfaces with an enamel, all of whose constituents are absolutely insoluble and infusible. (3) The permanent protection from decay of all wood by impregnation with a chemical solution. It is not intimated that wood will endure infinitely an increasing attack of flame without charring or disintegrating; but it is asserted that when wood which has been treated is attacked by long-continued flame, it will not receive, or increase, or transmit flame. To test the value of this system, two wooden houses were built. One was of treated wood, the other of natural wood. Under each house was placed a mass of yellow pine sticks, and on all sides were piled several cartloads of Georgia pine. In sixteen minutes after fire had been applied the untreated house was utterly consumed, while the treated house was but slightly charred. The door of the latter was then opened, and it was filled 5 ft. high inside with shavings and pine logs, and over all was distributed 10 gals. of coal oil. The mass was fired, and at the end of twenty-three minutes the door (which was not even burned through its panels) was opened. Although all the fire-wood was burned up, not a particle of flame adhered to the wood of the building. The chemical agent employed is sulphate of alumina, the strength of the solution being about 15 degs. Beaumé. In treating ties and bridge timbers, an addition is made of ferric sulphate to the alumina solution, this latter material acting as a coagulant. The solution in either case is applied under a pressure of 450 lbs. to 600 lbs. per sq. in., no preliminary steaming or vacuum process being employed. When flame or intense heat is applied to the treated wood the wood will char at the point of contact, but will not burst into flame. When untreated wood is coated with a paint of which the sulphate of alumina forms the basis, the application of heat causes the paint to form a rough, hard crust, which protects the wood beneath. In impregnating wood to render it fire-proof, cylinders of moderate size are used, each holding a single

railway tie, a timber of commercial size, or a bundle of planks, etc. The cylinders are of cast-steel, and tested to 1,000 lbs. pressure. Wood, textile fabrics, theatre scenery, etc., can be simply and effectively treated so as to eliminate all possibility of their receiving or extending fire. Thus far, consideration has only been given to the case of wood impregnated in a proper plant, and cannot therefore have any bearing upon the protection of existing buildings. But the author expects to solve the problem of interior-wood treatment by means of insoluble and infusible enamel coatings of any shade of colour. The same material may be used in a solution to be applied to draperies and scenery. It is not to be understood that this will render them absolutely immune to flame, but that it will nullify the inflammability which naturally exists in them.—**Joseph L. Ferrell,** *Jnl. Western Soc. Eng., Vol. IX, No. 1,* pp. 38–43.

CONSTRUCTIONAL.

Melan Concrete-Steel Bridge at Dayton, Ohio.

THIS bridge, to be built across the Great Miami River at Dayton, Ohio, will be in seven arches, with a total length between abutments of 710 ft. and a width of 62 ft. between balustrades. The foundations for the piers will rest directly on the hardpan under the thin layer of gravel and silt. Though of different spans and rise, the seven arches are symmetrical about the centre span, and have the following dimensions:—Nos. 1 and 7, span 80 ft., rise 9·67 ft.; Nos. 2 and 6, span 90 ft., rise 11·3 ft.; Nos. 3 and 5, span 100 ft., rise 13·25 ft.; No. 4, span 110 ft., rise 14·25 ft. The maximum ratio of span to rise, 8·1 to 1, is in arches 1 and 7, and the minimum ratio of 7·4 to 1 is in arches 3 and 5. The arches are all elliptical, struck with four radii. The roadway is 42 ft. wide, and will carry a double-track street-car line. It is flanked on both sides with 10-ft. sidewalks, the grade on the bridge being 2 per cent. from both ends towards the centre. Foundations for the piers and abutments will be sunk in open cofferdams of tongued and grooved sheathing at least 4 ins. thick. A 1 : 3 : 7 mixture of concrete is to be used in the piers and abutments for all work done in the open



CONCRETE-STEEL BRIDGE AT DAYTON, OHIO.

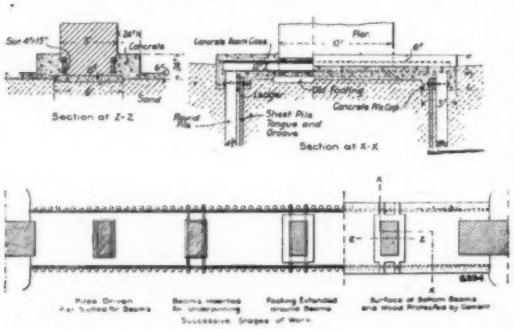
air. Both the abutments and wing walls are to be of a 1:3:7 mixture of concrete. The general construction is shown in Fig. 1. In all of the other spans the construction is substantially the same, except that heavier sections are used in the steel trusses. The steel reinforcement consists of twenty-two parallel trusses of the shape of the arch section, spaced across the arch 34 ins. apart and bedded in the concrete of the piers and abutments. These trusses are made up of a top and bottom chord of two angles each, connected with a single lattice-work throughout their length. The separate trusses are not connected together during erection except in the anchorages in the piers and abutments, where they are tied with two or more angles, extending the width of the arch. Over each pier the top chords of the trusses of adjacent spans are spliced together, forming a continuous reinforcement along the length of all seven arches. The top and bottom chords in each arch are also spliced at the crown and just beyond the haunches. In arches 1 and 7 the size of angle used is $2\frac{1}{2}$ ins. × $2\frac{1}{2}$ ins. × $\frac{5}{16}$ in., and in all the others 3-in. × 3-in. × $\frac{5}{16}$-in. angles are used, with $1\frac{3}{4}$-in. × $\frac{1}{4}$-in. lattice bars throughout. A machine-mixed concrete of 1 part cement, 2 parts sand, and 4 parts broken stone will be used in the arches. Concreting will be started simultaneously from both haunches in longitudinal sections, wide enough to include three steel ribs, each layer being well rammed before the previously deposited layer has taken its set. Two steel ribs, between which there is a dividing plane of two adjoining sections of concrete, will have the top and bottom flanges clamped together with straps, $\frac{1}{4}$ in. × 2 ins., bent around and under the flanges. These clamps will be spaced about every 10 ft. The copings, balustrades, and parapets on the wing walls will be made of concrete of a 1:2:4 mixture, faced with $\frac{3}{4}$ in. of cement mortar in the proportion of 1 of cement to $2\frac{1}{2}$ of sand, applied in the moulds or forms, and in no case to be plastered on after the moulds have been removed. After the completion of the arches and spandrel walls, and before the fill is put in, all of the exposed inside surfaces will be given a thick coat of cement grout, and after this has set hard a coat of pitch $\frac{1}{8}$ in. thick will be applied. In calculating the stresses in the bridge the following conditions were assumed:—

Dead load—Concrete	150 lbs.	per cub. ft.
Fill ...	120 ,,	,,
Pavement	150 ,,	,,
Live load—For roadways and sidewalks ...	150 ,,	per sq. ft.
Concentrated moving load	40-ton electric car.	
Modulus of elasticity of concrete	1,500,000 lbs.	
Do. do. steel ...	30,000,000 ,,	
Maximum stress on concrete—		
Compression, excl. of temp. stresses ...	500 lbs.	per sq. in.
Tension, excl. of temp. stresses ...	50 ,,	,,
Shear	75 ,,	,,

Maximum stress on steel in arches: The steel ribs, under a stress not exceeding 18,000 lbs. per square inch, must be capable of taking the entire bending moment of the arch without aid from the concrete, and have flange areas of not less than the one-hundred-and-fiftieth part of the total area of the arch at crown. Steel in the arch ribs must have an ultimate strength of from 60,000 lbs. to 68,000 lbs. per square inch, an elastic element of at least half the ultimate strength, and show an elongation in 8 ins. of 20 per cent., with a reduction of area of 40 per cent.—**Anon.,** *Rlrd. Gaz., Vol. XXXVI, No. 10,* pp. 154–155.

Saving a Sinking Concrete Arch Bridge.

A CONCRETE arch bridge, about 140 ft. long, which, when nearly finished, was threatened with immediate destruction, was saved by the building of an unusual kind of protection and reinforcement for its foundations. During the construction of the arches a storm scoured the bottom and destroyed all the false-work. This was renewed, and the concrete work was completed, and the stone filling over the piers and haunches had been nearly finished, when vertical V-shaped cracks appeared above the crowns of two of the arches. A vertical crack was also developed on the centre line of the pier between them, and on each side of it the face concrete was cracked. It was found that this pier had settled about 4 ins., and the others from 1 to 2 in. The broken stone which had been placed on the arches was removed, and piles 3 ft. apart were driven in parallel rows about 9 ft. each side of the bridge axis. Waling-pieces were bolted to the insides of these piles, and against them were driven 3-in. tongued and grooved sheet piles 15 ft long. It was not deemed safe to underpin the piers, but slots were cut on each side of each pier as low as could be reached at extreme low water, and in them were seated single 12-in., 32-lb. transverse I-beams, which took bearing on the round



A SINKING CONCRETE ARCH BRIDGE.

piles, and were wedged up against the top of the slot in the pier masonry. The beams were encased in solid masses of concrete, which were extended around all sides of the piers to a width and depth of 2 ft. The tops of the piles and the waling-pieces were enclosed in a mass of concrete about 3 ft. wide and 2 ft. high. This concrete extended about 2 ft. below low-water mark, and was embedded 1 ft. below the average surface of the sand. The space around the piers and cross-beams between the piles was covered with a 6-in. layer of concrete, forming a continuous floor over the whole area, which protected it from scour. Resistance to further settlement of the piers was thus provided by the transverse beams, and the bearing capacity of the soil and its stability were greatly increased by confining it between the sheet piles, and protecting its upper surface. The repairs, which were quite satisfactory, occupied about one month, and cost about $3,000. The concrete in the new footings and apron was made 1:3:6 with Portland cement and beach gravel up to 2 ins. in diameter. The concrete for the arches was made 1:2:5 with Portland cement and gravel from ¼ in. to 1½ in. in diameter. The arch rings were reinforced by full-width sheets of No. 10 expanded metal with 3-in. mesh, extending continuously from one springing line of the crown to the other, and stiffened with three semi-circular longitudinal steel rods, ⅞ in. in diameter.—**Anon.**, *Eng. Rec.*, *Vol. XLIX*, *No. 6*, pp. 171–172.

Freezing as an aid to Excavation.

This paper contains a synopsis of the result of a research of the literature on the subject of freezing as an aid to excavation in unstable material. All articles which could be found in the various libraries of New York City were examined and abstracted, and then combined in the following synopsis. The author first deals briefly with the history of the different processes, and then considers in detail the Poetch, Gobert, and Koch methods. The application of freezing systems is fully discussed, together with a description of the several mines in which sinking by freezing has been adopted. Finally the author discusses some other projects for, and actual applications of the freezing process, of which only brief mention was found in literature on the subject.—**J. H. Brace, A.M.Am.Soc.C.E.**, *Proc. Am. Soc. C. E.*, *Vol. XXX*, *No. 1*, pp. 20–91.

Burntisland Harbour: Construction of the East Dock.

The paper begins with a short historical account of the harbour of Burntisland, with special reference to the development of the town as a port for the shipment of coal. The construction of the new East Dock involved the reclamation of 37½ acres of land from the sea, and included the following work:—A rubble-mound sea-wall, 2,343 ft. in length, with 10-ton concrete bag-work forming the toe for the pitching; two concrete entrance-piers, 640 ft. and 412 ft. long, respectively, built by deposition of concrete between sheet piling below low water, and between timber profiles above low water; embankment works behind the sea-wall, formed with sand pumped from the sea-bottom; a dock-entrance 60 ft. wide, provided with dock- and sea-gates with 12 ft. 9 ins. over the sill at low water, and 28 ft. 6 ins. at high water, of ordinary spring tides; the construction of west, north and east dock-walls on shale and whinstone rock, and of pitched slopes on the south side of the dock, with concrete hoist-jetties; the construction of a new ferry-pier in place of the old one removed. The methods of carrying out the foregoing works are described, and also the materials used. A short account is then given of the erection of the new pumping-station; also of the hydraulic machinery, consisting of three coal-hoists with 40-foot lifts. One of these is a high-level hoist for return of empty wagons, the other two are low-level hoists. During the construction of the dock some trouble arose from the percolation of sea-water through the concrete walls, and the cracking of the north wall; the plan of dealing with this difficulty, by putting in a clay puddle wall across the line of travel of the water, down to the rock, is described.—**R. Henderson, M.Inst.C.E.**, *Proc. Inst. Civ. Engs.*, *March 29th*, *1904*.

The Use of Cement Grout at the Delta Barrage in Egypt.

In the paper, after reference to the successful restoration work carried out by Colonel Western to render the barrage efficient, the author describes the method of rendering the work still more secure by the use of cement grout for consolidating the defective lower layers of the foundation platform. Vertical bore-holes were made along the centre lines of the brick masonry piers, and carried down into the sand or clay underlying the barrage foundations. When a bore-hole had been successfully cleared to at least 1 metre below foundation level, cement grout was mixed and poured down the bore continuously, until the grout rose in the bore flush with the top. Altogether 774 separate bores were made, of an aggregate length of 7¾ miles. The total quantity of cement used was 6,094 barrels (of 360 lbs. each). The total cost of the operation was £6,027. It was shown that the pressure exerted at the bottom of the bores, tending to force the cement into interstices in the foundations, was in the case of most of the bores 2·4 tons per sq. ft., and in the case of the remainder 1·76 tons per sq. ft. The evidence obtained of the travel of the cement grout below the foundations is given. The paper then deals with the construction of the subsidiary weirs below the Delta barrage. After describing their object and design, the paper details the method of construction. The bed of the river was first dredged out to the form of the weir foundation line. The core and footing walls were then made by the employment of cement grout, the core-wall in 20 ft. of water and the footing-wall in 10 ft. The walls were made in successive blocks, but as continuous masonry without break, by forming boxes, carefully put together, along the wall alignment, the first box formed being a four-sided box, and all subsequent boxes being three-sided, the last formed block of masonry closing the fourth side. The box, having been put together and lined with

sacking to make it cement-grout tight, and having also been rigidly tied in position, was then filled with rubble of all sizes, after arranging perforated iron pipes along the axis of the box. When the box was full of stone to water-level, the cement grout was poured down the pipes in inner unperforated tubes, until the contained water had been displaced by the cement grout. The box and its contents were then left alone till the next morning, when, the cement having set, the box was taken to pieces, moved forward, and put together again, to form the next block in the same way. To put the boxes together, floating gantries on big barges were used in the case of the core-wall, and a specially-designed apparatus on pontoons in the case of the footing-wall. Divers were employed to assist in putting together boxes to ensure that all the parts were correctly fitted together. The cement and water were mixed into grout by unskilled labour, and the paper points out that one of the advantages of the method adopted for forming the sub-aqueous walls was that no skilled labour, other than two divers to each box, was required. The filling of the boxes with stone, and the mixing and pouring of the grout were performed by the cheapest labour obtainable; the putting together of the boxes only required care. Each core-block contained 165 cubic metres of grouted masonry, and took three to four days to make. Seven rafts with their gantries were the largest number at work at a time, and these turned out an average of 350 cubic metres of grouted masonry *per diem*. The author claims that by no other system could such rapid progress have been made, or such excellent sub-aqueous masonry be obtained. The paper then describes the manner of putting in the foundations of the two locks, associated with the weirs, by the same method of forming masonry by cement grout under water without any pumping. The lock area was enclosed by lateral walls made as the weir core-walls were made. The ends were closed by making a thin temporary wall in a similar manner, but by a special arrangement both these end walls and the lateral walls being carried a little above water-level. Grouting pipes were next arranged vertically, at about 10 ft. intervals, all over the enclosed area, and a layer of rubble 7 ft. thick was thrown in around the pipes to form the bottom layer of the floor. A platform was formed over the lock site between the enclosing walls, the upright pipes being used as the vertical supports. The cement grout was then poured down the pipes, commencing from one end of the lock, and the pouring continued until a float in an unoccupied pipe showed that the cement grout had risen 7 ft. from the bed. When this 7 ft. layer had set, the end walls were formed upon it by grouting, and the whole left for two or three days to set. The enclosed water was then pumped out in a few hours, and the lock was built on the grouted floor in the dry, all springs having been effectually excluded. The operation was perfectly successful in the case of both locks. The author claims for this method that a perfectly sound floor is obtained, as no troublesome springs create defects by forming a way under or through the masonry while under construction. The quantity of cement used was at the rate of 3·67 barrels of cement (of 360 lbs.) per cubic metre, or 40 per cent. The weirs and their locks were constructed in a little over three seasons, each season being of eight months duration. The total cost was £E.434,000. The construction of the weirs has not only relieved the barrage of part of the head of water it was called upon to hold up, but it has increased the maximum holding-up permissible from 4 metres to 6·20 metres. The author concludes his paper by a reference to other instances of the successful employment of cement grout in Egypt, and calls attention to the experiments carried out in India by order of Mr. R. B. Buckley, C.S.I., M.Inst.C.E., when chief engineer of Bengal, comparing the cost of results in the two countries.—**Major Sir R. Hanbury Brown, M.Inst.C.E.,** *Proc. Inst. Civ. Engs. March, 1904.*

The Barrage Across the Nile at Asyût.

THE paper describes the Asyût barrage, which was begun in 1898 and finished in 1902, at a cost, including subsidiary works, of £869,546, and insures a constant supply of water to Middle Egypt and the Fayûm. These parts chiefly receive their supply through the Ibrahimiyah Canal, which leaves the Nile at Asyût. The barrage was constructed across the river down-stream of the canal entrance, so as to be able to raise the river level during the spring and summer months high enough to allow of a sufficient supply entering the canal. This dam will serve Middle Egypt and the Fayûm in the same way as the one at the apex of the Delta serves Lower Egypt. Its construction has for many years been considered necessary by those who are acquainted with the requirements of Egyptian irrigation, independently of any decision to construct a reservoir at Assûan; though, of course, with an additional summer supply available, the carrying out of this project became even more advisable. The work, as a general rule, will not be in use during flood, the sluice-gates being then generally drawn up out of the way, to allow of the river flowing freely through the sluice openings, the aggregate sectional area of which corresponds approximately with the water-way of the river at this point. During exceptionally low floods, however, it may be called upon to raise the river level at such times also. The width of the river at the site of the work was 900 metres (2,953 ft.), and the length of the dam is 833 metres (2,733 ft.). The structure, in its manner of controlling the river, follows closely that of the Delta barrage, and is an arched viaduct resting on a broad, solid masonry floor foundation, laid at a suitable depth below the bed of the river. There are 110 piers, and the spaces between them can be closed when necessary by iron sluice-gates, which slide in vertical iron grooves, set in the sides of the piers. Two sluice-gates, 2·5 metres (8 ft. 2 ins.) high each, are provided for each opening; the gates are raised or lowered by overhead travelling winches, running on rails the whole length of the barrage. A lock,

16 metres (52 ft. 6 ins.) wide, for navigation purposes, is provided next the left bank. A subsidiary work undertaken was the construction of a regulator across the canal at its entrance, similar in design to the barrage, for the purpose of not only controlling the canal supply in summer time, but also sometimes partially closing the canal during ordinary flood times. The cost of this work was £136,000. The river-bed at Asyût is composed of fine sand, and when any part of it is exposed by pumping, the surface exposed is alive with innumerable springs. As this kind of bed extends to a great depth, a comparatively shallow foundation of great width was considered the most suitable for such a place. As originally designed, the foundations consisted of a masonry platform or floor 26½ metres (87 ft.) wide, with shallow brick wells through the floor and for a short distance beneath it under the sites of piers and abutments. The original design also included the sinking of a line of rectangular curtain-wells beneath both the up and down-stream faces of the floor, to prevent water from passing underneath. The consulting engineer, Sir Benjamin Baker, modified this design by increasing the thickness of the masonry floor foundation, and dispensing with the shallow wells under the bearing surfaces of the superstructure. The rectangular curtain-wells were also discarded, owing to the difficulty of being able to make watertight junctions between them; and cast-iron sheet piles, sunk to a greater depth, were substituted for these wells. The iron piles were made with tongued and grooved ends, the tongue being slightly shorter than the groove, to allow the joints being filled with cement grout, and thus made watertight. The bottom of this platform or floor is about 5·1 metres (16 ft. 8 ins.) below the low summer level of the river, or about 12 metres (39 ft. 4 ins.) below the ordinary high river level. The river level at the commencement and termination of each season's work was about 7·75 metres (25 ft. 5 ins.) above the bottom of the floor. Both lines of iron sheet piles are sunk 4 metres (13 ft. 1½ ins.) below the bottom of the floor, or 3 metres (9 ft. 10 ins.) below the depth proposed for the up stream curtain wells, and 2 metres (6 ft. 7 ins.) below the depth proposed for the down-stream ones. The bed of the river for a distance of 20 metres (65 ft. 7 ins.) from the masonry floor, on both the up and down-stream sides of the barrage, is thickly paved with rubble pitching. At extreme low Nile a cushion of water about 2·1 metres (6 ft. 11 ins.) deep exists on the floor on the down-stream side. A roadway for wheeled traffic is carried over the barrage, its surface being 41 ft. above the floor. The floor is of rubble masonry and concrete, the mortar for both being made with cement. The superstructure is of rubble masonry (dressed on the surface to a smooth face) the mortar being made with lime and burnt clay. Earthen dams, strengthened with sand-bags and rubble-stone, were made round the sites taken in hand from time to time, the water from such enclosures being pumped out. The bed everywhere met with was sand saturated with water, necessitating the use of many pumps. At one time twenty-eight centrifugals of various sizes were at work. The coal used in pumping amounted to 21,061 tons. The foundation floor was laid under many difficulties, owing to the innumerable springs encountered in the excavated trench, over 1,000 large springs, 7 ins. to 8 ins. in diameter, being met with. The construction and maintenance of the temporary dams had to be very carefully watched. The natural flow of the river during operations ranged from two to three miles per hour, but the velocity near the site of the work during construction was often in places as great as six miles per hour, owing to the obstruction caused by these dams. The total number of men employed during the busiest part of a season averaged about 7,500, though at exceptional times as many as 12,500 were at work. The quantities for a few of the chief items in the barrage and regulator are:—Temporary dams (a large number of rope nets, and a large amount of rubble stone and 2,697,000 sacks were used in this work), 642,370 cubic yards; rubble masonry and concrete, 210,222 cubic yards; stone pitching, 147,152 cubic yards. The chief difficulties in connection with the work lay in the foundations, the springs preventing any large portion of floor being laid at one time.—**G. H. Stephens, M.Inst.C.E.,** *Proc. Inst. Civ. Engs., March, 1904.*

Lowering the Sill of the Ramsden Dock, Barrow-in-Furness.

THE paper begins by pointing out that the entrances to most of the docks constructed more than twenty years ago are too shallow to take the largest vessels of the present day, and consequently the best means of making these entrances deeper becomes an important question to engineers and others concerned with the management of docks. The work now being undertaken in Liverpool is cited as an instance of the importance attached to the matter by the authorities of that port. Increased depth on the entrance to a dock is usually obtained either by building a new entrance alongside the existing one, or by lowering the sill of the existing entrance. The deepening of the No. 4 sill of the Ramsden Dock lock at Barrow-in-Furness is an instance of the second method. The contract for the work was let on June 8th, 1899, to Messrs. John Aird & Co., Mr. Frank Stileman being Chief Engineer. Besides the lowering of No. 4 sill of Ramsden Dock by 6 ft., a quay wall, 900 ft. long, on the south side of the basin, and another, 500 ft. long, on the north side, had to be constructed. The contract was let on the understanding that these quay-walls were to be completed before the lock was closed for the lowering of the sill. The main object with which the work was undertaken was to allow large battleships being built by Messrs. Vickers, Sons & Maxim to have access to the docks, as there was only 24 ft. of water on the existing sill, and the battleship then being built for the Japanese Navy had a draft of 27 ft. 3 ins. Sections of the quay-walls are given in the paper, and the work in connection with their construction is described. On the completion of these walls, cofferdams were built across the ends of the Ramsden Dock lock,

and the water was pumped out, so that the work on the sill might be done in the dry. The operations involved in this work were :—Removing the old gates; cutting away the old gate-floor; rebuilding the floor 6 ft. lower, so as to take a sliding caisson in place of gates; building a caisson-recess; and providing and installing a sliding caisson. Shortly after the lock had been pumped dry and the removal of the sill begun, an accident occurred through the water breaking under the pier-head on the north-east side of the lock, whereby the work was considerably delayed, as the cofferdam at the north end of the lock had to be lengthened before the water could be again pumped out. In consequence of this accident, which damaged the pier-head and showed the unreliability of the bottom, special precautions were taken in carrying out the remainder of the work; these consisted of driving cast-iron sheet piles in front of the old sill, and taking out the old floor in small squares. No further trouble was met with, and the new sill was completed on April 21st, 1901. The pier-head, which had been damaged by the water breaking through, was removed, and a timber head was built in its place. The coffer-dams were now removed, the sliding caisson was launched and floated into the recess prepared for it on the west side of the lock, and the lock was re-opened for traffic on May 17th, 1901. The sliding caisson, which takes the place of the old gates, was designed to take a head of water on either side, thus doing the duty of two pairs of gates; it also serves as a roadway, 12 ft. wide, across the lock, for heavy vehicular traffic. The caisson is tank-shaped, 103 ft. long, 12 ft. wide and 39 ft. 6 ins. deep. It has four watertight compartments so arranged that the caisson just does not float, thereby reducing to a minimum the friction when the caisson is being drawn across the lock. Hydraulic machinery is used for hauling the caisson to and fro, and also for working the sluices in the caisson.—**L. H. Savile, A.M.Inst.C.E.,** *Proc. Inst. Civ. Engrs., March 29th, 1904.*

Trench-Excavating Machinery.

Among trench-excavating appliances now made the writer considers that the Buckeye wheel-machine, and the machine made by the Municipal Engineering and Contracting Co., of Chicago, are the best. The wheel-machine has shown in use that conditions must be extremely favourable, and a limit in depth of 6 ft. seems the most economical. For greater depths the Austin excavator, having a chain with ploughs and cutters, is best. A large machine of the latter type is capable of cutting a trench of 16 ft. deep, and by the addition of an extension a further depth of 7 ft. can be secured, so that a 23-ft. trench can be dug if necessary. In the right kind of soil another 7 ft. can be added, making 30 ft. in all. The machines are not yet perfect, but they are money-makers. The machines have cut 750 lineal ft. of trench in 10 hrs. In St. Louis the Austin machine successfully cut about 300 ft. of reverse curve with 100 ft. radius. If large boulders are encountered the excavator is raised, and the stone cracked with dynamite in small charges. The excavator is dropped again, and the stones brought out with the earth regularly excavated; the raising and lowering of the excavator being all done from the machine by means of levers and wheels. Considerable experience with these machines, coupled with information received concerning others, leads the writer to the following conclusions: (1) A good trench-digging machine will excavate an ordinary trench at less than one-fourth the cost of hand-labour. On deeper trenches the proportion will fall to one-fifth or one-sixth. (2) If the weather is unfavourable it is best not to attempt too much. (3) The ground should be firm, to get the best results. (4) The vibration of the machinery causes the earth to settle more or less, and it is therefore best to plank all trenches. (5) For the above reason sandy soil and gravel are hard to work in, as the machine goes too fast for men to plank readily. (6) The machine is best adapted for pipe-sewer work. The construction of brick sewers is too slow, unless the trench can be excavated several hundred feet ahead, and left open a long time. (7) No machines have yet been brought to a state of perfection; it is therefore necessary to look over the ground carefully before deciding upon their use.—**Ernest McCullough, C.E.,** *Eng. News, Vol. L, No. 26,* pp. 562–564.

METALLURGY.

Phenomena due to Repetition of Stress.

Recently Reynolds and Smith have shown that the number of repetitions necessary for fracture is less the greater the rapidity with which they take place. Ewing and Humfrey have also shown that when a metal is subject to an increasing stress in the usual manner there is no visible structural change until the elastic limit is exceeded, and the extension becomes permanent. At this stage "slip bands" appear, due to a slip taking place in the crystals, and which accounts for the permanent extension of a metal stressed beyond its elastic limit. Prof. Ewing has further shown that a metal subjected to repetitions of stress less than the elastic limit, develops slip bands—in other words, the metal passes into the condition of one subjected to a statical stress greater than its elastic limit. When a metal is subjected to a cycle of loading within its elastic limit—as, for instance, from zero to a maximum tension and back to zero—at the end of the cycle a slight extension or lag will be found, which, however, disappears after a little time. If the cycle of loading is repeated before the bar has recovered, the lag at the end of the second cycle should be greater than at the end of the first. Ultimately the total extension, including the total lag, will be equal to the maximum elastic extension, and further extension will be permanent. A continuation results in fracture, the piece changing its shape as in a statical test. Slip bands when produced in the crystals are sources of weakness, and on removal of the load there will be no reduction of extension and little relative motion of the "slip" surfaces. On reversal of the load the

surfaces will slip over one another and by so grinding develop cracks which account for the special weakness of bars under alternation of stress. The mere removal of the load should give rise to only a little creeping of the surfaces; under such conditions the cracks would hardly develop and the extension would proceed until the bar fractured. This view is supported by the fact that for a given maximum stress the bar subject to alternations is immensely weaker than the bar subject to unidirectional stress: features illustrated in the following table :—

Material.	Simple Bending.		Bending Rotating Bars.	
	Stress Limits. Tons per Sq. In.	Repetitions.	Stress Limits. Tons per Sq. In.	Repetitions.
Iron for axles	0, (+) 15·28	3,400,000	(+)15·3,(−)15·3	56,430
Phœnix Company	0, (+) 14·3	48,000,000	(+)14·3,(−)14·3	99,000
Homogeneous iron	0, (+) 19·1	34,500,000	(+)18·2,(−)18·2	31,586

—F. Foster, B.Sc., *Mem. and Proc. Manchester Lit. and Phil. Soc., Vol. XLVIII, No.* 7, pp. 1–20.—*P. L.*

A New Testing Machine.

Most experimenters have adopted the method of rotating a bent bar, which does not yield simple stresses. Prof. Reynolds obtained simple alternating stresses by causing the specimen under test to reciprocate a dead-weight in a straight path. This machine is diagrammatically shown in Fig. 1. The specimen *S* transmits the force required to accelerate or retard the weight *W*, and is therefore subject to approximately equal tensile and compressive stresses. Owing to mechanical and lubricating difficulties the alternations are limited to about 2,500 per min., and the alternations are only approximately equal. The machine illustrated in Figs. 2 and 3 is designed to eliminate these difficulties. It consists of a piston *P* fitting into a cylinder *C*. Fixed in the cylinder is a transverse plate *S* with ports cut in it; resting against this plate, and rotating in the cylinder, is the valve *V*, with ports in the transverse portion and a second set in the circumferential rim. *B* and *A* are respectively steam chest and admission ports. The valve is driven by the spindle *W*, and as it rotates the valve *V* first admits steam to the cylinder, then cuts it off and exhausts it through the plate *S*. In this way the piston *P* receives a succession of cycles of loading. The specimen is fixed at S_2 for experiments under compression, or, if for tension, at S_1. The crosshead *H* is connected to the piston by side-rods provided with stops to limit the motion when the specimen breaks, and

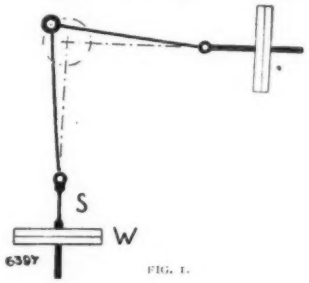
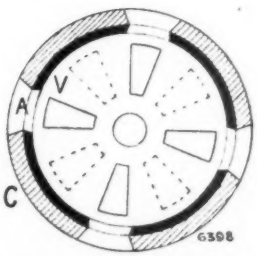
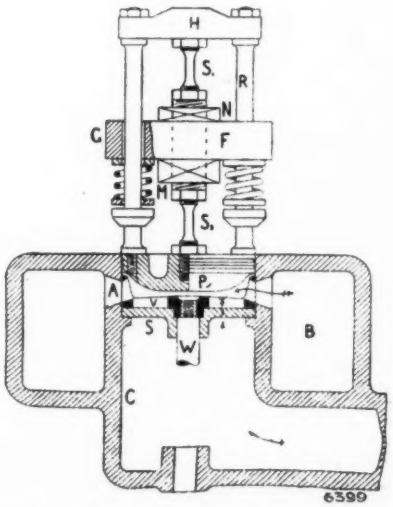


FIG. 1.



PLAN OF VALVE AND PORTS

FIG. 2.



NEW TESTING MACHINE.

FIG. 3.

running in guides to prevent the piston jambing. The pressure at which the piston is worked may be determined by indicators on the steam chest and exhaust space below *S*, or by indicators on the piston itself. The advantages of the machine may be summarised as follows: No reciprocating parts, highest frequencies of loading, frequency and loading may be varied independently of each other, and any limits of alternate tension and compression may be obtained by a slight modification of the machine.—**F. Foster, B.Sc.,** *Mem. and Proc. Manchester Lit. and Phil. Soc., Vol. XLVIII, No. 7*, pp. 1–20.—*P. L.*

Chrome Steels.

Two series of steels have been examined, one comparatively low in carbon, and the other containing about 0·8 per cent. carbon. Of the first series, the contents of carbon and chromium with the corresponding results obtained from tensile, shock, and hardness tests are included in Table I., following:—

From the tensile results low carbon chrome steels may be classified into three groups—(1) from 0 to 7 per cent. chromium, representing steels of similar properties to ordinary carbon steels, but of higher breaking loads, the latter increasing with a rising chromium; (2) steels containing from 7 to 22 per cent. chromium, which have a high breaking load, high elastic limit, low extension, and low reduction of area; (3) steels exceeding 22 per cent. chromium, of relatively low elastic limits, low breaking loads, and with elongations and reduction of area relatively high. Steels of this class, from their tensile results, approach those of high nickel or manganese content. The results obtained from the Frémont test also permit of the steels being divided into three groups: (1) non-fragile steel containing from 0 to 7 per cent. chromium; (2) steels containing from 7 to 22 per cent. chromium, which offer an average resistance to shock; and (3) fragile steels in which chromium exceeds 22 per cent. If these results are compared

Table I.—First Series.

Carbon %.	Chromium %.	Tensile.				Frémont Test, Kilogram-metres.	Hardness, Brinell.
		Maximum Stress.	Elastic Limit.	Elongation %.	Reduction of Area %.		
0·043	0·903	35·4	22·6	25·0	74·9	32	95
0·058	1·207	56·4	42·9	14·0	58·2	20	134
0·214	4·502	60·3	56·5	15·5	62·1	25	160
0·071	7·835	150·6	99·7	3·5	7·5	9	364
0·114	9·145	143·1	129·6	2·0	4·5	10	351
0·154	10·136	139·3	101·7	1·0	0	9	387
0·142	13·603	86·6	50·4	1·5	7·5	3	277
0·382	14·522	100·1	89·3	2·0	7·2	3	241
0·210	22·060	65·7	89·5	13·0	24·5	2	170
0·244	25·306	57·3	40·1	17·5	52·5	1	179
0·464	31·746	57·5	43·3	12·0	50·4	1	156

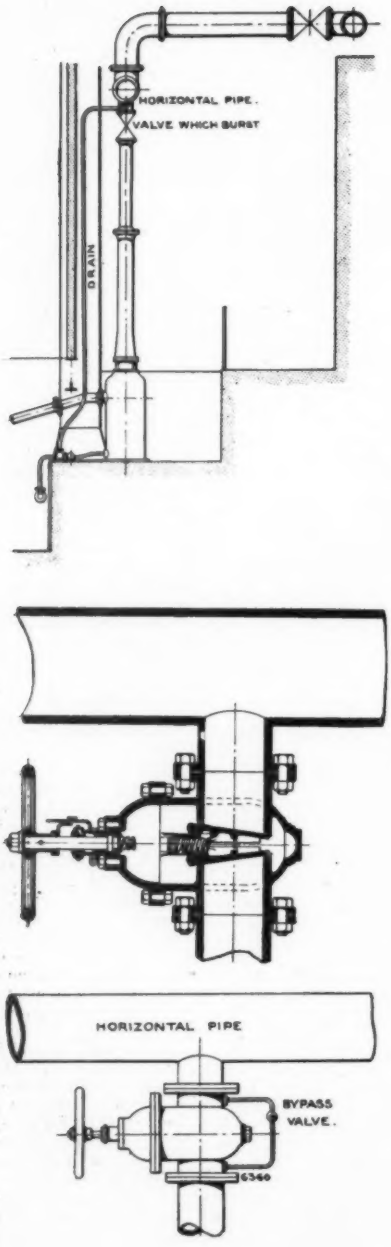
Table II.—Second Series.

Carbon %.	Chromium %.	Tensile.				Frémont Drop Test, Kilogram-metres.	Hardness, Brinell.
		Maximum Stress.	Elastic Limit.	Elongation %.	Reduction of Area %.		
0·965	0·519	109·2	79·1	2·5	16·6	3	310
0·973	0·986	131·8	131·8	3·5	7·5	2	332
0·887	2·141	139·3	97·9	2·5	0	3	364
0·789	4·570	133·3	84·4	3·0	7·5	3	293
0·840	7·279	124·3	60·2	3·0	17·6	5	377
0·751	9·376	94·1	79·1	13·0	0	3	387
0·961	11·521	132·5	79·1	5·0	14·7	1	321
0·741	14·538	120·0	65·5	1·0	0	6	477
0·903	18·650	128·0	128·0	0·5	0	2	387
0·820	26·541	59·3	48·9	10·0	45·1	1	170
0·916	32·560	67·8	56·4	13·0	40·8	2	187
0·838	36·340	—	—	—	—	2	228

with the tensile ones it will be noted that steels of the third class, which are very fragile, show in the tensile test comparatively high elongations and reduction of areas. This clearly demonstrates the fact that shock tests give results other than those furnished by the tensile test. Second series.—The results obtained from this series are embodied in Table II., above. The tensile tests divide the carburised chrome steels into three classes—(1) steels containing from 0 to 5 per cent. chromium, possessing similar properties to ordinary carbon steel, but with relatively higher elastic limits and breaking loads, these values increasing with a rising chromium; (2) steels of 5 to 18 per cent. chromium, possessing high breaking loads accompanied by relatively low elastic limits; (3) steels exceeding 18 per cent. chromium of low elastic limits, and breaking loads accompanied by high reductions of area. The Frémont test shows all the steels to be fragile; it may, however, be noted that the 14 per cent. chromium alloy is less fragile than the others. The hardness test indicates two classes—(1) hard steels containing from 0 to 18 per cent. chromium, and (2) steels of average hardness exceeding 18 per cent. chromium. Finally, a correlation of the micro-structures with mechanical properties show that untreated chrome steels may be grouped into three characteristic classes—(1) Steels of similar structures to carbon steels. These steels have a high elastic limit and maximum stress, both of which increase with the content of chromium, whilst the extensions and reduction of areas remain high, irrespective of the amount of chromium. The hardness increases with the content of carbon and chromium, and is always higher than ordinary steels of the same carbon content. (2) Steels of a martensitic structure. These steels when highly carburised apparently show more troostite than martensite. They have high breaking loads and elastic limits, low elongations, and reduction of areas. Members of this class are hard, and when the content of carbon is low they present an average resistance to shock. (3) Steels of special structures showing numerous white areas of double carbide of iron and chromium. These steels have a breaking load and elastic limit relatively low, but show comparatively high elongations and reductions of area. They are very fragile and of feeble hardness.—**Léon Guillet,** *Rev. de la Métall., Vol. I, No. 3,* pp. 155–183.—*P. L.*

New Autographic Method to ascertain the Critical Points of Steel and Steel Alloys.

THE classical methods employed to detect the critical points on heating or cooling are those of Osmond and Roberts Austen. In the former method a Le Chetalier thermo-couple is placed between two pieces of the steel under treatment, the heating and cooling being effected in a single or jacketed crucible; whilst, by means of a tape delivered by a Morse instrument, the time required by the index of the galvanometer to pass one division is noted. From this record a curve is constructed of which the abscissæ correspond to temperature, and the ordinates to time. Roberts Austen's modification of Osmond's method is as follows:—A piece of platinum is subjected to the same treatment as the steel examined, both being in contact with a thermo-couple. The temperature of the steel is obtained from the deflections of one galvanometer, whilst the second couple in contact with the platinum and connected in opposition with the first, indicates on a second galvanometer the difference of temperature between the two. The beam of light reflected by both galvonometers is received on a sensitive plate moving proportionately to time. From these two curves the necessary factors are obtained, and by means of a graphical construction the position of the critical points ascertained. In this method two variables are considered: the temperature of the steel, and the difference of temperature between the steel and the platinum, which would yield a very sharp curve of the phenomenon if the apparatus were made to register a curve having the temperature as abscissæ and the difference of temperature as ordinates. In order to achieve this the author has modified Roberts Austen's apparatus by placing the galvanometers so as to cause a horizontal deflection in the beam reflected by one mirror, and a vertical deflection of the beam reflected by the other mirror. The beams of of light are thus received on the mirrors of two galvanometers, one having a vertical axis of rotation, and the other a horizontal axis; the mirrors being placed at the conjugate foci of a lens. Any light proceeding from one of the mirrors is in this way evidently received by the other mirror, and the desired combination of the two oscillations is obtained. By the advice of M. Pellin the vertical axis of the galvanometer has been retained, and the transformation into a vertical plane obtained by passing the beam through a totally-reflecting rectangular prism. The various parts of the apparatus are as follows: (1) A source of light sending a parallel beam upon the mirror of the galvanomer recording the difference of temperatures. (2) A sensitive galvanometer with a mirror reflecting the light at an angle of 90° in a horizontal plane. (3) A totally-reflecting prism transforming the horizontal into vertical oscillations. (4) Lens, at the conjugate foci of which are placed the mirrors of the two galvanometers. (5) Galvanometer recording the temperatures, with mirror reflecting the light at an angle of 90° in the horizontal plane. (6) Objective receiving the beam of light and condensing it upon a screen. (7) Ground-glass screen to follow the phenomenon, or photographic plate to photograph it. Instead of platinum nickel steel, containing 25 per cent. nickel, may be used; and as the critical point of this steel is below 0° it is well adapted for this purpose. The possible applications of this outfit are numerous, and it is possible to record all the phenomena which may be represented by a function of two variables, provided these two variables may be represented by the proportional rotation of a mirror in the many instances when the mirrors must turn round two parallel axes. The method is specially applicable in the case of two variables which can be represented by a proportional electro-motive



CAUSES OF THE BURSTING OF CAST-IRON VALVES.

force, as is the case with a temperature observed by means of a thermo-electric couple, or with the distance travelled along the thread of a potentiometer, etc., the rotation of the mirrors being obtained by means of a galvanometer. — **E. Saladin,** *Iron and Steel Metallst., Vol. VII, No. 3,* pp. 237–252.—*P. L.*

A Decade in American Blast-Furnace Practice.

THE author, in a paper read before the American Institute of Mining Engineers, reviews improvements in blast-furnace practice. Of these the four most important factors are—(1) the use of waste gases under boilers; (2) the heating of the blast; (3) the use of coke as fuel; and (4) the use of lake ores. Each of these steps has doubled or trebled the output. Improved refractory materials, better engines, and wider chemical knowledge were essential; but these influences should be regarded as secondary and logical sequences to the others. Transportation facilities, handling of stock, slag and pig-iron, the utilisation of by-products, and various features in furnace design, are also noted. The introduction of blast-furnace gas engines denote an important epoch, and by combining the duties of boiler and blowing engine economies amounting to 20 per cent. are promised. Some 297,050 h.p. is now available. In speaking of blast-furnace working the following quotation is not without interest: "Impressive as is the metallurgical practice of America, it exhibits inventive ability less than natural resource. We owe more to the regions named after Père Marquette than we do to original research. It is true we have the Uehling pyrometer, of American origin, which is an instrument of great precision and of great value to the furnace man. Our records, however, are characterised by bold application rather than new ideas."— **F. Louis Grammer,** *Iron Trade Rev., Vol. XXXVII, No. 8,* pp. 51–54.—*P. L.*

PRIME MOVERS.

Causes of the Bursting of Cast-Iron Valves in Steam Pipes.

THE author deals in detail with a number of accidents of the above description which have happened in various steam plants in France of recent years. These accidents have in most instances happened when steam has been admitted into a pipe or range of pipes which contained water of condensation, and have in general been attributed to water-hammer. While agreeing that in many cases the water, acting as a liquid piston, may be dashed with great velocity against a valve or blank flange, and thus cause fracture, the author maintains that this action is not responsible in every case for the fracture. Experiments show that if steam at 70 lbs. per sq. in. be admitted to a pipe 23 ft. long and 1 ft. diam. slightly inclined, and containing water to a depth of 9 ins., shocks take place, and when the pipe admitting steam was 3⅛ ins diam., and the steam was admitted above the water surface, the pressure was raised to 400 lbs. per sq. in. by these shocks. Still higher pressures

were obtained by using a 2½-in. pipe, and by leading the steam into the main pipe below the surface of the water. In another experiment, steam was led at 150 lbs. per sq. in. into a reservoir, into which cold water was injected by a tube 1⅞ in. diam. and 4 ft. 9 ins. long, perforated for the second half of its length. Violent shocks were produced corresponding to each stroke of the feed pump, and these shocks continued even after the pump stopped. They are attributed to the sudden condensation of steam upon the surfaces of the jets of water issuing from the tube. In one particular accident which happened to the valve marked in the accompanying sketches, it seems impossible that the rupture was due to water-hammer. In the first place the range of pipes was well drained, and the drains were fully opened just before the accident. The following are the circumstances of the accident. The particular engine to which this valve admitted steam had been standing for some hours, so that some water would have accumulated in the short vertical length above the valve. The horizontal pipes were well drained by drain pipes at intervals of about 22 ft., leading to a steam trap. On wishing to re-start this engine, the cock which drained this horizontal pipe was opened, and the valve *V* was being opened, when a series of violent shocks were felt which finally caused a violent rupture of the valve body. The following seems to be the explanation of the accident. When a mixture of steam and water, at a high pressure and temperature, expands to a lower pressure adiabatically, the proportion of water in the mixture is increased, the temperature falls, and mechanical work is done. In the accident in question, we may assume that there were still some pounds of water in the vertical leg of the pipe above the valve when the valve was being opened. This water would be at a high temperature, since the steam with which it was in contact was at 155 lbs. pressure, and on opening the valve the pressure would be suddenly reduced, and a sudden violent expansion of the mixture of steam and water would take place, with an accompanying transformation of heat into mechanical work in the form of kinetic energy. The cast-iron of the valve being unfitted to stand a shock of this kind, rupture took place. To avoid accidents of this description the author advises the fitting of by-pass valves between the two sides of any large steam valve, so that the pressure on the two sides may be equalised before the main valve is opened.—**Sylvain Périssé,** *Ingenieur des Arts et Manufactures, Membre de la Commission Centrale des Machines à Vapeur, Gén. Civil, Vol. XLIV, No. 14.—A.H.G.*

Efficiency Test of 1,250-Kw. Steam Turbine for Interborough Company, New York City.

DESCRIPTION and results of tests on a Westinghouse-Parsons steam turbine, of the two-cylinder, multiple-expansion, parallel-flow type, direct connected to the generator, which is of the revolving-field type, delivering three-phase, 60-cycle current at a pressure of 11,000 volts. The unit operates at 1,200 revolutions per minute, and the

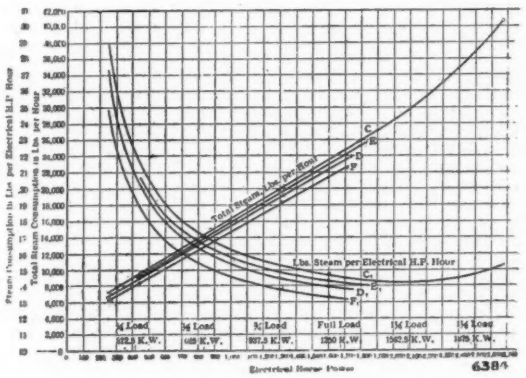


FIG. 1

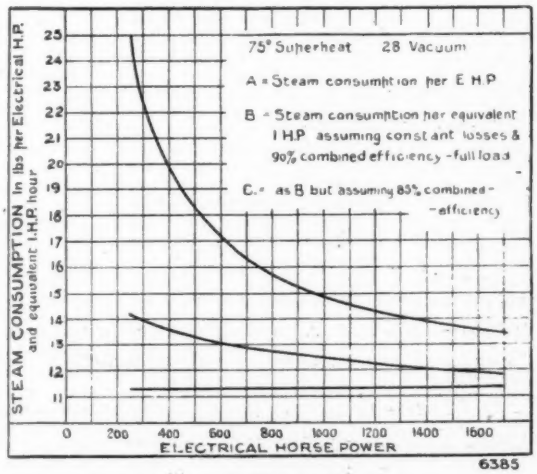

75° Superheat 28 Vacuum
A = Steam consumption per E.H.P.
B = Steam consumption per equivalent I.H.P. assuming constant losses & 90% combined efficiency - full load
C = as B but assuming 85% combined efficiency
STEAM CONSUMPTION in lbs per Electrical H.P. and equivalent I.H.P. hour
ELECTRICAL HORSE POWER
6385

FIG. 2.

EFFICIENCY TEST STEAM TURBINE.

conditions of test approximate those of daily service. Overload capacity up to 50 per cent. of normal rating is secured by a hand-operated by-pass valve, admitting high-pressure steam to the second stage of the turbine, the by-pass being regulated so as to keep the speed constant at all loads. The author fully describes the method of taking all the measurements during the tests, the results of which are shown graphically in Fig. 1, in which curve *C* represents steam consumption using dry saturated steam and 27-in. vacuum; curve *D* represents steam consumption using 75 degs. Fahr. superheat and 26-in. vacuum: curve *E* represents steam consumption using dry saturated steam and 28 in. vacuum; curve *F* represents steam consumption using 75 degs. Fahr. superheat and 28 in. vacuum. Gauge press at throttle is 146·5 lbs. in all cases. Curve *C* shows very clearly the effect of the by-pass in raising the steam consumption at loads over 1·3 of the normal rating. In Fig. 2 the curves *A*, *B*, and *C* show how the steam consumption compares with that of a reciprocating steam engine, in which a combined efficiency of 90 and 85 per cent. respectively is assumed, and where the losses due to friction, etc., are taken to be constant. In the latter case, the indicated water-rate of the turbine is 11·26 lbs., and is constant at all loads.—**A. M. Mattice,** *Elec. Wld., Vol. XLIII, No. 8,* pp. 356–360.—*A.H.G.*

On Cylinder Condensation and Valve Leakage in Steam Engines.—III.

IF in Fig. 1 (Part II.)* the temperature depth curves had been drawn for every crank angle, we should find that the surface gradients are horizontal, when the crank angles are 315° and 135°, and, therefore, for any position of crank between 135° and 315°, say 270°, heat is leaving the walls, while for any crank angle, say 360°, between 135° and 315° in the other direction, heat is flowing into the walls. This neglects the flow of heat due to radiation. The same result is obtained by differentiating expression (7) with respect to x, putting $x=o$, and finding what value of α makes this expression $=o$. From (7) we get—

$$\left[\frac{dv}{dx}\right]_o = -Am(\text{Sin}\,\alpha + \text{Cos}\,\alpha) \quad \ldots \quad (8)$$

and since the heat entering during a short time dt is $dQ = -k\left[\frac{dv}{dx}\right]_o dt$ $\therefore$ the whole heat entering or leaving each square foot of wall surface per cycle =

$$-\int k\left[\frac{dv}{dx}\right] dt = \int kAm(\text{Sin}\,\alpha + \text{Cos}\,\alpha)\,d\alpha \quad (9)$$

between the limits $\alpha = 315°$ and 135°. This gives

$$Q = \sqrt{2}\,\frac{kAm}{\pi N} \quad \ldots \quad \ldots \quad (10)$$

thermal units per square foot of wall surface area per cycle. Substituting for m its value—

$$\left(m = \sqrt{\frac{\pi N c}{k}}\right)$$

we get—

$$Q = \sqrt{\frac{3{\cdot}88}{N}}\ {\cdot}2A \quad \ldots \quad \ldots \quad (11)$$

where $2A$ is range of surface temperature of walls. Taking a surface range of 100° Fahr., we obtain the following table:—

Revolutions per minute = N	25	50	100	200	300	400	500	600
Heat abstracted per square foot per cycle = Q ...	39·4	27·9	19·7	13·9	11·4	9·8	8·8	8·0

In certain American experiments performed on the engines of the *Bache*, at 46 revolutions per minute, with steam at 90 lbs. initial pressure absolute, non-condensing, the amount of steam used was equivalent to 1 lb. for every 48·2 sq. ft. of wall surface, and 0·474 of that 1 lb. condensed upon the wall, and therefore 1 sq. ft. of the wall received 8·74 T.U. But from the table we see that 1 sq. ft. would have required 30 T.U. to make its range 100° Fahr., and this therefore shows that the wall surface does not vary nearly so much as the temperature of the steam. In fact its range could only be—

$$\frac{8{\cdot}74}{30} \times 100 = 29° \text{ Fahr.}$$

—**Prof. J. T. Nicholson, D.Sc., M.Inst.C.E.,** *Power, Vol. XXIV, No. 1,* pp. 8E–9E.—*A. H. G.*

Passage of Heat within a Boiler-Heating Surface.

THE author records some series of observations where the influence of certain experimental conditions on the passage of heat in the same steam-boiler heating surface was established. The composition of the furnace gases was calculated, by taking into account the chemical composition of the fuel and the amount of air in excess, as determined from the free oxygen contained in the gases. The main results of these researches are based exclusively on the validity of the law of Mallard and le Châtelier, as to the dependence of the specific heat of gases on temperature. The first experiment shows the co-efficient k of the passage of heat to increase about proportionally to the increase in the temperature difference with respect to the heat absorber. In the remaining experiments, the influence of an alteration in the water circulation within the heating surface on the passage of the heat through the same heating surface was ascertained and the dependence of the absorption of heat on the nature of the heat-bearer was evidenced. It is shown that with equal efficiency of the heat-producing process and with the same fuel, the initial temperature will be the less, the more steam there will be in the heat bearer, while

* Cf. p. 366.

the heat capacity of the furnace gas with equal final temperatures will be much higher than with a heat bearer containing small amounts of steam. —**P. Fuchs,** *Zeitsch. des Vereines Deutscher Ingenieure, Vol. XLVIII, No. 11,* pp. 379-385. —*A. G.*

Using Waste Heat from a Gas Engine.

In this paper the author describes and gives the results of certain experiments carried out to determine the degree of economy obtainable by utilising some of the heated gases in the exhaust of a gas engine for the purpose of superheating the steam supplied to a steam engine, and also by utilising some of the waste heat in the jacket water of the gas engine to heat the feed water of the steam engine. The gas engine used had a 9-in. by 16-in. cylinder, running at 200 revolutions and developing 12 h.p. The steam engine also had a 9-in. by 14-in. cylinder, and developed 6 i.h.p. at 200 revolutions. The results of tests show that an average economy of 14 per cent. was obtained using the combined plant with superheater only. When, in addition, the jacket water was utilised to heat the boiler feed, an economy of 21 per cent. was obtained over that of the plant running as two separate units, and developing the same h.p. The author concludes that a primary engine of three to four times the power of the secondary would give the best results.—**H. B. MacFarland,** *Engineer, Vol. XLI, No. 5,* pp. 174-176.—*A.H.G.*

Explosive Mixtures.

In this paper results of a series of experiments are given, which show that explosions of mixtures of coal-gas and air of less than $\frac{1}{11}$th of the whole volume, are accelerated and made more forcible by replacing some of the excess of air by products from the previous explosion. Results of experiments are also given, determining the rapidity of the explosive action with mixtures of gas and pure air, varying from ·127 down to ·064, with a compression of 40 lbs. per sq. in. in each case. The mixtures were pumped into a cylinder fitted with a series of four electric igniters, so that very rapid and certain inflammation of the mixture should result. With a mixture of ·127 of gas of the whole volume of mixture, a maximum pressure of 350 lbs. was reached in $\frac{1}{10}$th of a sec.; with a mixture of ·10, *i.e.* 1 of gas to 9 volumes of air, a maximum pressure of 310 lbs. was obtained in $\frac{1}{10}$th of a sec.; with a mixture of ·091 a pressure of 240 lbs. was obtained in about $\frac{3}{4}$ths of a sec.; but with a mixture of ·086, combustion was very slow, the maximum pressure only being reached after $1\frac{1}{2}$ secs. from the moment of ignition; while with a mixture as poor as ·064 combustion was scarcely perceptible. In another series of experiments with a compression of 15 lbs. per sq. in., and with a constant mixture of gas of ·067 of the total volume of the cylinder contents, the effect of varying percentages of inert products from the previous explosion are given. With an absolutely pure mixture of gas and air of this very poor degree and low compression, a very delayed combustion and maximum pressure of only 25 lbs. resulted, the time occupied being $1\frac{1}{2}$ sec.; but with a replacement of burnt products for air equalling 10 per cent. of the vol. of the cylinder, a pressure of 50 lbs. was reached in $1\frac{1}{10}$th sec.; with a replacement of burnt products equalling 40 per cent., a pressure of 85 lbs. was obtained in 1 sec. from the moment of ignition; and with a dilution of the mixture with products of combustion equalling as much as 50 per cent. of the total volume, a pressure of 140 lbs. was obtained in $\frac{1}{3}$rd of a sec. The time allowed to elapse between the pumping in of the charge of compressed mixture into the explosion cylinder and the moment of ignition is not stated, nor are particulars given of the temperatures of the cylinder walls nor of the mixtures, both of which factors are of great importance in determining the exact comparative results from explosive mixtures of different values. —**L. Bairstow, A.R.C.Sc.,** and **A. D. Alexander, A.R.C.Sc.,** *Engineering, Vol. LXXVII, No. 1993.—E.B.*

The Crossley Variable Cut-off Valve.

In order to minimise throttling of the explosive mixture supply at reduced speeds in car petrol motors, a rotating valve is used, having one large wedge-shaped port, which opens to the induction mixture pipe at the commencement of the stroke of each of the four cylinders used, but closes sooner or later with a sharp cut-off action by the endways sliding of the valve under control of an ordinary centrifugal governor At full speed communication between the cylinder and carburetter is continued for the whole stroke, when running slow the cut-off may be as early as one-fourth of the stroke. By this method of speed control an advantage in economy and efficiency is obtained at reduced speeds by avoiding loss of power through the throttle as generally used; this method also tends to equalise the suction on the carburetter, and to give a more constant mixture.—*The Automotor Jnl., Vol IX, No. 8.—E. B.*

MARINE ENGINEERING.

Screw Propellers.

The engines of all future British Naval ships are to be so designed that the screw-propellers will turn outwards for driving the vessel ahead. For some time past it has been the practice to arrange the engines for inward-turning screws, but experience has shown that this entails a loss in manœuvring powers, and also in propulsive efficiency, especially where the propellers are close to the hull of the ship. This view, which is entertained by many officers in the service, has been confirmed by some experiments which have recently been carried out in Italy. In the French Navy experiments have been made with the same result, and, as a consequence, it has been decided that all small cruisers and torpedo-craft shall be fitted with out-turning screws. Our Admiralty, however, have made the change operative in all ships. One of the advantages

of the in-turning screw was that the engineers' platform could be in the centre of the ship, so that he had full control and view of both engines. In the merchant service this advantage is got even with out-turning screws, but to obtain this result it is necessary to have heavy columns in the front of the engines to take up the thrusts of the cross-head and connecting-rod. This would involve heavier engines—an important factor in warships; besides, would restrict the view of the engines. In naval machinery round forged-steel columns are now used in all cases, and the engineer in charge can see all parts at a glance, and can ascertain easily if any part of the machinery shows a tendency to heat. In the new cruisers the starting platforms will be in the wings of the ships, the back columns of the cast-iron form with slipper guides for the thrust of the crosshead and connecting-rod, being placed next to the longitudinal bulkhead which separates the two engine-rooms. —**Anon.**, *Steamship, Vol. XV, No. 177*, p. 349.—*H. B. D.*

Producer Gas Plant for Ship Propulsion.

THE recent development of steam turbines opens a prospect that, in the near future, this type of engine will replace reciprocating steam-engines on board ship for even the largest powers. For smaller powers, however, the steam turbine has hitherto failed to prove its superiority as regards economy over the steam engine, and at the present moment it seems as if the range from, say, 25 to 500 or even 1,000 h.p. would be the special field for gas engines and producer gas. For stationary purposes the "Dowson" plant is the best known. Gas is produced in it by blowing (under pressure) a mixture of steam and air through glowing fuel, the gas being cleansed in a coke scrubber or similar arrangement before storing it in a gas holder. When it was found that the initial pressure was not necessary, but that the engine itself could suck the steam and air mixture through the fuel and the resulting gas, a considerable simplification of the gas plant was possible. Instead of a boiler for generating steam under pressure, a vaporiser could be used, heated by the gas itself on its way to the cleansing apparatus; and by producing the exact quantity of gas required for driving the engines, the gas-holder could be dispensed with. Fuel economy, immunity from danger by explosion, and small amount of space occupied, extreme simplicity, and low cost of attendance and repairs are some of the advantages inherent to this system. M. Emil Capitaine, who first perfected the oil-motor and adapted it to marine purposes, has now succeeded in designing a gas plant which seems to fulfil all the special requirements for success on board ship. The vaporiser is placed inside the generator, concentrically with the iron shell, and above the combustion chamber of the producer. The movable trough grates are of a novel design, immensely simplifying the removal of clinker and ashes, and reducing the corrosion of the grate to a minimum. The purification of the gas is effected in a small cylinder, in which water, by means of compressed air and a spray nozzle, is divided into the finest particles in the form of mist, which washes the gas in a most perfect manner. After the gas has been washed, the moisture, tar, and particles of ash are separated from it by means of centrifugal force, thus ensuring the greatest purity on reaching the engine. This plant is manufactured, as far as possible, of wrought steel, to ensure the lowest weight whilst maintaining the utmost rigidity. In the smaller sizes the design is of the two-cylinder type, and in the larger sizes of the three- or four-cylinder type. The engines run at a moderate speed. The piston, cylinder, valves, ignition device, and combustion chamber are all accessible simultaneously. The governor can be set for any speed by hand while the engine is running. The lubrication of all parts of the engine is effected by one single central automatic lubricator, actuated by hydraulic pressure, but also adjustable by hand. The consumption of fuel amounts to one-third of that of a steam engine. Engines over 200 h.p. are made reversible, while below that power reversible propellers are fitted.—**B. Wiesengrund, Ph.D., M.E.**, *Marine Engr., March 1, 1904*, pp. 470-473.—*H. B. D.*

Report concerning the Design, Installation, and Operation of the Turbine Engines of SS. *Revolution*.

THE reports of the board to witness the performance of the steam turbines submitted to the Department of the Navy Bureau Steam Engineering, Washington, contains a number of interesting facts relative to the performance, and gives some valuable suggestions for guidance in future installations: (1) The turbines above referred to are of the Curtis two-stage compound marine type, reversible and condensing. They are two in number, directly connected to the thrust and propeller shafting, each set of turbines driving one screw of about 4 ft. 6 ins. diameter, and 3 ft. 4 ins. pitch. (2) The most noticeable feature observed was the almost entire absence of vibration or disturbing noises usually attending the running of fast-moving reciprocating engines, and the slight care needed while in operation. These turbine engines are easily started, stopped, and reversed, the time required for each operation being only that necessary for the opening and closing of a set of valves connecting the turbine casings with the main steam pipes. At full speed ahead the vessel turned readily either to starboard or port in thrice her own length. Dead in water, and starting one propeller full speed ahead and the other full speed astern, the vessel turned in her own length. Dead in water, with helm hard a-starboard, and then going ahead on the port propeller, the vessel turned readily to port. (3) Running full speed ahead with both screws, and then suddenly reversing the engines, the ship was brought to a standstill in 30 secs.; the same conditions with one screw required about 38 secs. At low speeds about the same amount of time for reversing was required. The only place where any vibration was felt was directly over the propellers, due probably to want of a more perfect balance. (4) The trials not being carried out with a view to ascertain any data of efficiency or steam consumption, the only

information obtainable that should convey any idea regarding the economic efficiency of the plant is an abstract from Prof. J. E. Denton's Report on the Curtis Steam Turbines for the yacht *Revolution*, in which it is stated that at 672 revolutions per minute an equivalent power of about 1,800 i.h.p. was developed by both turbines at a steam consumption equal to 18·14 lbs. per i.h.p. This is believed to be excessive, owing to the use of steam in two stages only. With four-stage turbines the steam per i.h.p. should be reduced well within the margin of prevailing average for marine engines. A noticeable occurrence was the sudden drop in steam pressure at full power, indicating the inability of the boiler installation to furnish the requisite amount of steam needed for the efficient working of the turbines. (5) The general installation of the machinery afforded sufficient room for the proper care and handling of the motors. The forced-draught blowers, six in number, all on one shaft, were driven by a small Curtis turbine, running at about 2,800 revolutions per minute. The generator in the electric plant was similarly driven. (6) The clearance spaces between the stationary and running blades of the revolving drum being made extremely small, and there being no flexible coupling arranged for between the turbine shaft and the thrust shaft, the bearing of the latter was provided with a hand-wheel mechanism actuating a yoke, so arranged as to maintain the original clearances by sliding the thrust-block on its sole-plate; propeller, shafting, and turbine-drum all moving together. The wear on the thrust-block was very slight. This adjustment is only rarely resorted to. (7) The turbine shaft bearings run in oil, which is continually circulated and cooled by water coils connected with the oil pump, no water circulation being used direct on the journals. Water circulation is, however, used on the thrust bearings. (8) The exhaust from each turbine issues from a casing of the upper half of the secondary stage through a 20-in. pipe into the condenser. The condensers are of the ordinary type, with about 1,100 sq. ft. cooling surface each. The air pump is a double Blake featherweight $\frac{6 \text{ ins.} \times 12 \text{ ins.}}{8 \text{ ins.}}$ placed forward of the turbines and below the working platform. A vacuum of 28 ins. is maintained without any trouble. A number of other auxiliaries are fitted, consisting of an auxiliary condenser and feed-water heater, feed-pumps, etc. All the auxiliaries are placed in the engine-room, excepting the auxiliary condenser, which is placed on the boiler-room floor. (9) The boiler plant consists of two Seabury double-ended water-tube boilers of 94 sq. ft. grate surface, arranged for forced draught. (10) The main turbines consist principally of the casings, nozzles, and revolving drums containing the bucket wheels and shafts. The steam enters at a pressure of 250 lbs. through four steam nozzles. After acting consecutively upon a series of bucket wheels constituting the "first stage," in which the steam expands down from 260 lbs. absolute to about 16 lbs. absolute, it flows through four other nozzles which form the second stage, and there expands to less than 1 lb. absolute, with condenser vacuum of 28 ins., the work done by the steam upon the buckets being thereby really equalised. (11) Reversing is made possible by placing vanes on the outer rim pointing oppositely to the ahead buckets, all enclosed in the casing of the second stage. A separate steam pipe leads to this part of the casing, and steam is admitted by a separate valve. (12) The general ease with which the machines are cared for and handled is due to the great simplicity of the mechanism when compared with the ordinary reciprocating engine. The space occupied, judged in the light of a casual observation, is rather more than that required by engines of the torpedo class, but as there is not the same amount of overhauling necessary, the extra space can well be spared. The weights of the turbines in this case are alleged to be 8¾ lbs. per equivalent i.h.p.; those in torpedo-boat engines run about 11½ lbs. per i.h.p. (13) The opinion of the board with regard to the efficiency and the economy of the machines in comparison with the best marine engines is that more extended tests should be made: such tests, it is believed, will eventually result in the application of a motor for screw propulsion highly satisfactory to the Naval Service. (14) Additional fore-and-aft space will be required for any efficient installation of turbines. This fact should be well recognised so that all parts of the mechanism will permit frequent and necessary overhauling from the engine-room. (15) As the turbine is more dependent upon high vacuum than a reciprocating engine, it is essential that the main condensers and main air pumps must be favourably placed for ready examination and overhauling. (16) In order to maintain the requisite vacuum, the auxiliary appliances should not exhaust into the main condenser. (17) It is an absolute necessity that the main throttle and main reversing valves be perfectly tight.—**A. B. Canaga, Commander U.S.N.; J. R. Edwards, Lieut.-Commander, U.S.N.; W. M. Parks, Lieut.-Commander, U.S.N.,** *Journal of Amer. Soc. of Naval Engr. Vol. XV, No, 4,* pp. 1241-1246.—*H.B.D.*

Steam Raising by Means of Oil.

It is stated by Mr. J. F. Rowland, in the Journal of the Franklin Institute, that if oil were obtainable at a low enough price it would have many advantages over coal when used for steam raising. Its heat of combustion is about 19,000 Th.U., as against 12,000 for ordinary coal. Moreover, when the latter is fired by hand, the frequent opening of the furnace door, allowing the cold air to strike the heated plates and tubes, is a fruitful source of trouble. Coal also leads to the deposit of soot in the tubes, and the ashes left over require removal. All these drawbacks are averted when oil fuel is used. In one plant of over 4,000-h.p. capacity, the oil is atomised by steam, but air, at a pressure of 3 ins. of water, is also supplied and facilitates combustion. In regular every-day practice 14·1 lbs. of water (reduced to, from, and at 212 degs. Fahr.),

are evaporated at this plant per lb. of oil consumed. The boiler tubes were cleaned out once a month, as compared with every day when coal was used; and hitherto no repairs have been needed to the furnace or tubes since the oil-burning plant was first put to work—seven months ago.—*The Steamship, Vol. XV, No. 176,* p. 297.—*H. B. D.*

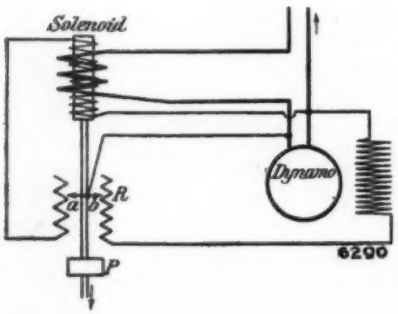
Calcium Carbide.

A NEW use for calcium carbide (for raising and sinking submarine boats) has been discovered in Germany. The boat is supplied with an ordinary gas generator and a water tank, the upper part of which is connected with the gas reservoir of the generator. The tank and generator have pipes at the bottom opening into the sea. The upper parts have vertical pipes for the escape of the gas. If the tank and the reservoir of the generator are filled with water, the boat sinks. After the introduction of a carbide cartridge into the gas generator an immense quantity of gas is immediately generated, which forces the water through the lower pipes into the sea. After opening the cock in the connecting pipe, the gas enters the tank and fills it by forcing out the water. The boat now rises to the surface, remaining there until the gas is allowed to escape from both reservoirs, which causes them to be again filled by sea water.—*Steamship, Vol. XV, No. 176,* p. 290.—*H. B. D.*

ELECTRICAL ENGINEERING.

The Routin Electro-Mechanical Compounding System.

M. ROUTIN, of Lyons, has recently succeeded in designing regulators for steam-driven dynamos which fully satisfy the requirements of acting on the machine at the moment of an alteration of the load taking place, instantaneously adjusting the in-put corresponding with the altered load, while the speed remains unaltered. The apparatus consists mainly of an iron core acted upon by an attractive force corresponding to the difference between the ampère windings of one main-current coil and a tension coil. The main coil is traversed by the actual total current yielded by the machine, whereas the shunt coil—being connected in opposition to the main-current coil—is branched off from the terminals of the generator, and contains, in series, a resistance which, according to the position of the sliding contact *A*, is either increased or decreased. Simultaneously with the sliding contact *A*, a similar contact *B* is moved along, influencing through its altered position with respect to a resistance, *R*, the excitation of the machine. The dimensions of the two coils are so designed that the effect of the shunt coil always exceeds that of the main-current coil. The iron core of the solenoids is rigidly connected to the pieces acting on the in-put, bearing a weight *P*. In the case of the iron core being moved downwards, the in-put is increased; while a diminution takes place in the case of an opposite movement. The movement of the iron core is due to the differential effect of the ampère windings.—**F. Brock,** *Elektrotechn. Zeitschr. Vol. XXV, No. 2,* pp. 28–29.—*A. G.*



THE ROUTIN ELECTRO-MECHANICAL COMPOUNDING SYSTEM.

Some Causes of Supertension in High-Tension Plants.

THE author points out the fact that discharges due to supertension in high-tension plants were formerly in most cases quite harmless, while at present they are frequently the main cause of breakdowns in spite of the better insulation now generally employed. This, the author thinks, is due to the increasing extension of the wire system, and especially to the increasing use of underground cables, augmenting the capacity and self-induction of the plant. It is shown that increasing the capacity and self-induction may, in fact, result in supertensions being produced. — **Dr. G. Benischke,** *Elek. Rund., Vol. XXI, No. 8,* pp. 75–76.—*A. G.*

Floating and Booster-controlled Batteries for Fluctuating Loads.

THIS paper discusses very fully, and illustrates with numerous diagrams, the application of storage batteries, with or without boosters, to the regulation of the fluctuations of current and e.m.f. on a traction system; not merely as regards the equalisation of the load at the power-house, but also in limiting the variations of voltage on the line at considerable distances away. It is assumed in the calculations that a regulating battery may be discharged at its one-hour rate as a maximum, and recharged at the same rate, giving 1·915 volts and 2·14 volts per cell under these conditions respectively; and 2·025 volts per cell when neither discharging or recharging. If a "floating" battery—*i.e.* one connected directly across the mains without a booster—is installed at the power-house, it considerably reduces the fluctuations of the generator load, and therefore the size of generator necessary; but the station voltage falls rapidly with increase of load, and consequently, an excessive amount of copper has to be put into the line feeders, and the regulation of pressure at the feeding

points is unsatisfactory. A more uniform line voltage may be obtained with less copper by using an over-compounded generator without a battery; but if it can be combined with a floating battery at the end of long feeders, the equalisation of the load is so much improved that the saving in generating plant and line copper will, in some cases, more than pay for the cost of the battery. In this arrangement, provision may have to be made to prevent the battery receiving an excessive charging current when there is no load on the line, should such a condition be liable to occur. If a battery and booster are installed at the power-house in conjunction with shunt-wound generators, the load on the latter will be almost constant, and they need not be nearly so large as when a floating battery only is employed; a further saving of feeder copper will also be effected. If a battery and booster can be installed at the far end of a feeder, a still more uniform line voltage is maintained; but extra attention is then necessary, and it is generally better to keep them in the power-house and spend a little more on line copper; besides, it is only occasionally that any one feeder is so long, or carries so large a portion of the load, as to justify a battery to itself; while the other arrangement meets the ordinary case of numerous feeders of not greatly differing lengths. In general, booster-controlled batteries have the advantage that they can be made to regulate the fluctuations of load independent of the degree to which they have been discharged, and their recharge and overcharge is effected without the need for resistances or other special devices. The paper includes some account of the principles of action of the different types of boosters, and concludes with an examination of a regulating system for preventing an excessive fall of voltage over a long line, by means of a "constant-current" booster at the power house supplying a floating battery at the far end of a long feeder.—**Lamar Lyndon,** *Elec. Rev. N. Y., Vol. XLIII, No. 22,* pp. 770-774, *No. 23,* pp. 815-817.—*E. J. W.*

The Distribution of Electricity in Shipyards and Engineworks.

THE first consideration in designing a distribution system for an engineworks and shipyard is the choice of a system to be adopted—(1) for power, (2) for lighting. Some engineers advocate three-phase, and others direct-current throughout. The author's opinion is strongly in favour of a combination of the two systems—namely, three-phase for power and direct-current three-wire for lighting. Distribution from a power company is invariably on the three-phase system. Thus it would appear that the three-phase should be used throughout; but where there is a large motor load, as well as lighting, it is preferable to have both systems. The motor load on the three-phase system does not affect the lighting load off the direct-current system—a most important consideration. Three-phase motors are much more cheaply maintained, and stand overload to a much greater extent and length of time than direct-current motors. To get full advantage of electric driving in engineworks, however, direct-current should be available for driving a few variable-speed machines. Most of the author's data are in connection with three-phase motors. A short description of the two types in general use, with their respective advantages and disadvantages, is then given. (1) Those with a squirrel cage or short-circuited rotor, started by means of a compensator, which reduces the voltage at the terminals of the motor, the transformer portion being cut out by means of a throw-over switch when the motor has attained maximum speed. (2) Those with a drum-wound rotor. Three ends of the winding are connected to slip-rings on the spindle, and the other three ends are "star" connected. Resistances are inserted between the armature winding by means of slip-rings when starting. These resistances can be either cut out by a controller, which also operates the primary circuit, or by a regulating switch, with a triple-pole switch for the primary. This, in future, will be referred to as the slip-ring motor. The chief difference between the two is the starting current. The squirrel-cage motor takes about 2½ times full-load current for full-load torque at starting, whereas the slip-ring motor gives about full-load torque when taking full-load current. The slip-ring motor is from 10 per cent. (for the larger sizes) to 20 per cent. dearer than the squirrel-cage motor, and the latter type is a little more efficient and less complicated. For ordinary use, therefore, the squirrel-cage motor is the better, although it has to be heavily fused if started up against a load, as is necessary in many cases in shipyards. On the other hand, it requires much less attention, and the wiring is not so complicated and expensive. For such machines as winches and cranes the slip-ring motor is the only one which will prove satisfactory. Most of the machines in a shipyard should be separately driven. They have as a rule to be spaced far apart, which would increase the amount of shafting required to drive them in groups, and they have also to work intermittently. The following figures, taken from a shipyard shed, and until last January driven by a 50-h.p. Crossley gas-engine through a friction clutch, illustrate the amount of power wasted in shafting. Most of the shafting has been done away with, and squirrel-cage motors installed with very beneficial results.

Gas Engine.

Period of test, Feb. 16th to July 16th, 1902.

Total gas consumption = 1,380,000 cub. ft. at 2*s.* 6*d.* per 1,000 (less 20 per cent.)	£138	1	0
Man in attendance	48	0	0
Water	4	11	0
Oil and stores...	5	0	0
	£195	12	0

The average daily gas consumption was about 8,320 cub. ft., and the average i.h.p. about 62. Of this the i.h.p. required to drive the main and counter shafting was about 40. The attendance expenses above do not include cleaning and repairs beyond the ordinary cleaning and oiling daily.

Three-phase Motors.

Period of test, Feb. 16th to July 16th, 1903.

	Motors.	H.P.
Six punching and shearing machines, with a 7½-h.p. motor on each ...	6	45
One 27-ft. × 1½-plate rolls	1	30
One scarphing machine and plate-edge planer	1	10
Do. do.	1	10
One 6-ft. 6-in. × 1-in. straightening roll, two countersinks, and one grindstone	1	10
Two countersinking machines ...	1	5
	11	110

Units consumed = 32,916 at $1\frac{1}{8}$ = £145 14*s.*, representing a saving of £49 18*s.* per half-year. On a full day's work the costs of running, as taken above, are about the same for both systems. In engineworks, where sometimes direct-current motors are essential, separate mains should be run from the substation, but these motors should be as few as possible, and connected across the outers of a three-wire system. Current consumption is not much reduced by separate driving, for as a rule all the machines are running simultaneously, and not intermittently, as in a shipyard. On the other hand, a great advantage is gained by being able to space the machines independently of the shafting. For driving large cranes in constant use it has been proved that three direct-current motors give the best efficiency; but the first consideration should not be efficiency, but reliability from breakdown. The use of the three direct-current motors, with commutators, controllers, resistances, and complicated wiring, all tend to increase the possibility of breakdown. On the other hand, a single three-phase squirrel-cage motor has very few electrical connections. The three-phase type necessitates the use of a square shaft and friction clutches for the longitudinal traverse of the crane itself, but these require less skilled attention, and capital cost is less. The paper is concluded with a number of interesting figures, taken from the three-phase motors connected with the Newcastle Electric Supply Company's system. —**J. A. Anderson,** *Inst. of Elec. Engs. (Newcastle section).—H. B. D.*

Single-phase Railway Motors.

So far all motors suitable for railway work are of the commutator type, with series characteristics similar to those of the direct-current series motor. They may be divided into "straight series" type (see Fig. 1) and "transformer series" type. The latter may again be subdivided into those whose armature or field is supplied by an external transformer (see Fig. 2) and those known as repulsion motors, where the transformer is part of the motor itself (see Fig. 3). The arrangement shown in Fig. 2 may be considered as a true series motor, and yet possesses most of the characteristics of the repulsion motor. To obtain a high power-factor in straight series motors it is important that, relatively to the applied voltage, the voltage across the armature circuit should be as high as possible, and that across the field circuit as low as possible, for the latter very closely represents the wattless component supplied to the motor. This condition implies but few ampere-turns and a low saturation of the iron in the magnetic circuit; and this in its turn gives rise to certain characteristics in the torque curves of such motors which have been cited as showing their superiority over direct-current motors, whereas the latter would give the same results if normally worked at as low an induction. The power-factor may also be increased by reducing the air-gap, but this is limited by practical conditions; and for railway work a large clearance is probably of more importance than an extremely high power-factor at normal loads. The author proceeds to a comparison of the qualities of straight series and repulsion motors, and claims that the starting conditions (which are of more importance than the running conditions) are superior in the former as regards torque and sparking at the brushes, due to the short-circuited coils.—**B. G. Lamme,** *Amer. I.E.E. Discussion, Jan. 1904, Report Elec. Wld., Vol. XLIII, No.* 7, pp. 316-9.—*E. J. W.*

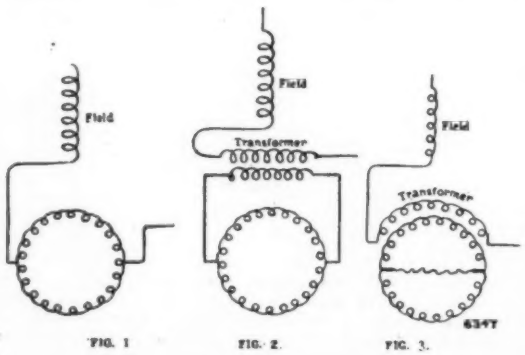


FIG. 1 FIG. 2. FIG. 3.

SINGLE-PHASE RAILWAY MOTORS.

Three-phase Working at Dublin.

THE Dublin system of three-phase generation and distribution of electricity is unique in this country, and in this paper the author selects some of its chief features as a text for the discussion of the principles and practice involved. Current is generated at 5,000 volts, 50 periods, and generators with star winding and an earthed neutral point are employed in preference to mesh winding, because with the former arrangement the pressure tending to break down the insulation of the machines is only 57 per cent. of that between the line wires transmitting the power. It also avoids troubles from harmonics and idle currents circulating in closed mesh windings.

Single-phase transformers grouped in threes are used in the sub-stations, and their advantages over single three-phase transformers are examined under the heads of—(1) Capital cost per kilowatt installed; (2) weight per kilowatt installed; (3) efficiency; (4) suitability as regards working conditions. The distribution from the sub-stations is by means of four-core cables, the consumers being connected between each phase and the fourth or neutral wire; and as against three-core cables, with the consumers connected between the phases, the system has the following advantages: (1) A greater amount of energy can be transmitted for a given capital cost, just as in a continuous-current three-wire system; (2) there are less variations of pressure due to want of balance amongst consumers; and (3) less inconvenience to consumers in the event of any of the phases being interrupted. Experience in Dublin shows that considerable weight attaches to this latter point. On the other hand, a four-core cable has a greater pressure between its conductors, and necessitates extra expense as regards fittings in house service boxes, etc.—**William Brew,** *Paper read before I.E.E. Dublin, Report Electrician, Vol. XLII, No. 14,* pp. 533-5; *No. 16,* pp. 617-9; *No. 17,* pp. 657, 658.—*E. J. W.*

Voltage Regulation in Alternating-current Systems.

Broadly speaking, the economy of an alternator design for a given frequency and speed is governed by two laws—(1) The output is directly proportional to the armature ampere-turns times the magnetic flux. (2) The cost of a design varies almost as the square of the variation in the air-gap diameter. On the other hand the good regulation (*i.e.* uniformity of voltage under all loads) of the machine depends upon the following conditions:—(1) The ratio of field ampere-turns to armature ampere turns should be large; (2) The self-induction and ohmic drop of the armature should be low; (3) The magnetic leakage between the poles should be small; (4) The magnetic densities in the poles should be high; (5) The flux distribution should be such as to produce a sine wave. The first condition has a most decisive bearing on the quality of the regulation, and to satisfy it either a small number of armature ampere-turns or a large number of field ampere-turns must be chosen. The former alternative conflicts with the first law, the latter with the second law; so in actual practice the designer has to compromise between the two whenever close regulation is required. Having discussed in detail how far and by what means the other conditions can be provided for in the design, the author proceeds to point out that not only the size and cost but also the efficiency and stability of operation of alternating-current generators are unfavourably influenced by attempting too close a regulation. Owing to their low armature reaction and self-induction they will exhibit a large short-circuiting current which may specially cause trouble in plants such as are required for rolling mills and mining work; and there will also be difficulty in parallel operation with reciprocating engines if the cyclic irregularity inherent in the latter is not kept down by an extra large fly-wheel effect.—**H. S. Meyer,** *Paper read before the Liverpool Eng. Soc. Report Electrician, Vol. XLII. No. 18,* pp. 701-703.—*E. J. W.*

Action of Light on the Velocity of Formation of Accumulators.

The author some time ago observed in connection with the formation of accumulators a reducing action exerted by light, the negative plates, if exposed to light, being formed more rapidly than in the case of their being left in the dark. This phenomenon was further investigated by comparative tests on two Tommasi accumulators, composed of a glass vessel filled with acidulated water, and containing three negative and two positive plates, one of which was exposed to the action of sun-rays, while the other was completely withdrawn from the action of light by means of a protecting cover. These two accumulators, after having been connected in series, were submitted to a charge ranging between 2 and 3 amps., when, after no appreciable difference had been noted during the first thirty hours, the negative plates exposed to light began to take a more strongly grey colour, an evidence of their being more advanced than the negative plates left in the dark. This experiment constitutes a definite confirmation of the above phenomenon. Now, by an analogous experiment, the author succeeds in showing that the positive plates of an accumulator will, under otherwise equal conditions, be formed more rapidly in the dark than in the light. In addition, there are certain permanent differences in colouration between the plates, both negative and positive, of accumulators, according as they are formed either in the light or in the dark, while their capacity proves identical.—**D. Tommasi,** *Écl. Élec., Vol. XXXVIII, No.* 7, pp. 241-243.—*A. G.*

TRACTION.

Design of Locomotives and Motor Cars for High Speeds.

With a view to determining the resistances to which high-speed vehicles are exposed, the author had made experiments for speeds up to 100 km. per hour as far back as 1879 and 1880, in Alsace Loraine, and in 1901 on the lines of the Hanover district, it being shown that the resistances concerned may be divided into two items: the one constituting the friction resistances, while being dependent on the weight of the car, proves independent of the speed, whereas the remaining resistances, increasing along with the square of the speed, are partly due to the shocks undergone by the car (depending accordingly on the weight of the car) and partly to the air resistance, which is conditioned both by the shape and dimensions of the car. Now, as for the highest attainable speeds the latter item plays by far the most important rôle, the author considers theoretically the air resistance of different surfaces. The results

thus obtained are next applied to determining the resistance of the Siemens & Halske high-speed car used in connection with the Zossen-Marienfelde trials, it being shown that by a suitable alteration of the surfaces and cover of the truck, a speed as high as 160 km. could be obtained with the same expense of work which at present is necessary to ensure a permanent speed of 140 km. A suitable design of steam locomotive is next considered, it being shown that such a locomotive would be efficient up to speeds as high as about 220 km. per hour. For a similar performance the locomotive would require about 16 cbm. of water per hour. It is finally pointed out that even for speeds of about 80 to 90 km. per hour, it would mean a considerable saving of coal to give the locomotive a more suitable design, making any projecting parts as small as possible.—**A. Frank,** *Zeitsch. Vers. Deutsch Ing., Vol. XLVIII, No. 2,* pp. 46–50. —*A. G.*

The 20-h.p. Hutton Petrol Engine.

An illustrated description of a neatly-designed petrol engine, constructed by Messrs. Willans & Robinson to the designs of Mr. T. W. Barber for J. E. Hutton, Ltd. Its most noticeable characteristic is that all twelve cams—operating the inlet-valves, the exhaust-valves, and the igniters—are mounted on one shaft, whilst provision is made for varying both the time of ignition and the lift of the inlet-valves. The cylinders have a bore of 90 mm., and the stroke is 120 mm. The normal speed of the engine is 900 revolutions per minute, and the maximum is about 1,500 revolutions per minute.—*Automotor Jnl., Feb. 27th, 1904,* pp. 256–7.

A Powerful Automobile Train.

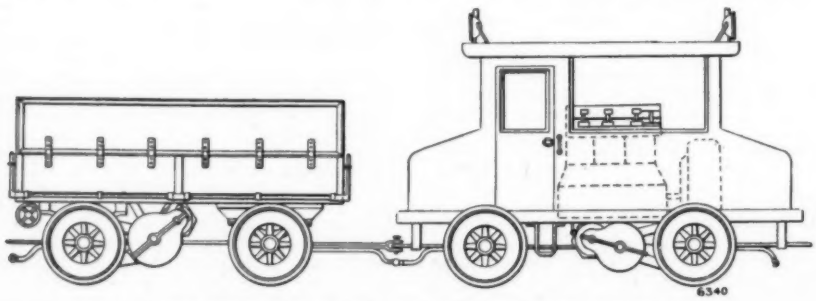
This is a train constructed for hauling borax out of Death Valley, California, consisting of the tractor containing the power plant and seven cars. The power is electrically transmitted to one pair of wheels under each car. The power plant consists of a three-cylinder four-cycle engine of 75 h.p., directly connected to a G. E. generator. The current is delivered through a controller to motors on the driving wheels of the tractor and of each car, the advantage being that the paying load of the train is utilised for adhesive weight, and therefore it is not necessary that the tractor have adhesion enough to pull the whole train. Each car has a capacity of 30,000 lbs., and weighs, empty, 9,600 lbs. They are almost entirely of steel, the frames being structural shapes. The cars dump by means of swing side-doors. Wheels are of flange-boiler type, and connection is made with the motors by means of chains. The train is equipped with Westinghouse air-brakes supplied from a motor-driven compressor in the tractor. The tractor is steered in a similar manner to the ordinary automobile, and the trailer-cars are constructed with a fifth wheel and tongue, the tongue of each car coupling to the rear of the car ahead, so that when the direction of the tractor is altered each trail-car follows in practically the same arc of a circle.—*Rly. Age, Vol. XXXVII, No. 7,* p. 231.

Brakes for Electric Cars.

The author discusses at considerable length the various methods of retarding cars, and deals in succession with mechanically, electrically, and pneumatically controlled brakes, and also refers to the subject of electric disc and rheostatic brakes. The paper concludes with a description of electrical track brakes, and it is stated that in all forms of magnetic track brake the retarding effect of friction between shoe and rail is assisted, as in the electric disc brake, by eddy currents produced in the sliding surfaces. The effect is similar to that obtained when a metal disc is revolved in a magnetic field.—**W. Park,** *The Tramway & Railway World, Vol. XIV, No. 29,* p. 573.—*C. S. L.*

Novel Types of Steam Locomotives.

The author describes a high-speed locomotive designed by Messrs. Henschel & Sohn, Cassel, for commercial speeds of about 130 km. This locomotive is being tested on the Marienfelde-Zossen military railway, in connection with the steam locomotive high-speed trials organised by the Prussian Railway Department as an indirect consequence of the famous electric traction trials. This engine has two trucks and two driving axles, a heating surface of about 260 sq. m., and about 4 sq. m. of grate-surface, corresponding nearly perfectly with the conditions



MOTOR AND ONE CAR OF BORAX TRAIN FOR DEATH VALLEY, CALIFORNIA.

enunciated in 1902 in connection with the High-Speed Railway Competition of the Verein Deutscher Maschineningenieure. Another type of locomotive described by the author is the superheated steam locomotive designed by Dr. H. Mehlis, to whom one of the prizes in the above competition was awarded. The engine is a 2–6 coupled tender-engine, with front and rear truck. This type was chosen on account of the fact that tenders of the usual design—even in the case of the water capacity being as high as 20 cub. m.—have too small a distance between the wheel centres for warranting a steady run with speeds ranging between 120 km. and 150 km. per hr.; moreover, their axles would not have a sufficient load after the provisions were used up. The distance of the wheel centres is 12·4 m., and the boiler axle is, in accordance with American practice, placed at a distance of 2·55 m. above the upper edge of the rail. The locomotive has four cylinders, with four cranks acting on the rigid front axles. The weight of the engine, at no load, is about 58 tons, whereas the working weight is estimated at about 76 tons. Of the heating surface in contact with the water, measuring 146 sq. m., about 126 sq. m. are intended for hauling the train, while 20 sq. m. are reserved for the electric lighting (generated by a 15-h.p. Laval steam turbine), the operation of ventilators, braking, heating, etc.; in addition, 34 sq. m. of superheated heating surface are provided.—**M. Buhle,** *Ding. Polyt. Jnl., Vol. CCCXIX, No. 8,* pp. 123–125.—*A. G.*

Construction of Steel Railway Wagons.

THE paper begins with a comparison of the physical qualtiies of timber and steel. The limit of elasticity of white oak is nearly equal to the ultimate strength, and the modulus of elasticity is low, so that a timber frame, by reason of the extent of its elastic deflection, has great capability of absorbing shock. The lateral stiffness of planking is greater than that of unstiffened steel plates of equal weight. The joints of wooden frames are a source of weakness. Rectangular sections are alone practicable for timber beams; the safe load on a rolled joist is compared with that upon an oak beam of similar depth, and the section and weight of beams of equal strength are compared. In British practice solebars, headstocks, longitudinals, and transoms are usually of similar section; in Continental practice the inner members are shallower than the soles, crossing above or below each other, thus simplifying the joints at points of intersection. The ratio of the load-gauge to rail-gauge is considered; the inadequacy of the former is stated to be due to the restrictive influence of the design of rolling stock with rigid wheel-base. The use of bogie trucks is considered to be desirable when the weight on the axles is increased; the adoption of bogie lead or apparatus to control the lateral and angular deflection of bogies is recommended. Bearing-springs in series are to be preferred to single springs of greater flexibility. The practice of arranging the side frames of the bogie and the axle-box springs and axle-guards in the vertical plane through the centres of the journals is preferred to the usual European practice of setting back the frames and axle-guards to provide room for laminated springs over the axle-boxes. The designs illustrated may be considered as an embodiment of the idea that a steel wagon should be a complete structure, in which all parts necessary for containing the load contribute to the strength and stability of the whole, whilst the component parts are plain rolling-mill shapes of standard section, assembled without the aid of special forged or pressed work. The sides of the wagons are formed of plate girders, of which the depth is so considerable, in relation to the span, that deflections under working load are quite inappreciable. Special stress is laid upon self-discharging vehicles, on account of the great economy effected by their use in the manipulation of minerals and other bulk freight at terminals. The ends of these wagons and the lower parts of the sides converge to openings at a suitable height above the rail-level. A special form of door which travels on horizontal guides is described. The prominent features of these doors are the facility they afford for providing a long base-line for intersection of the end slopes, their security against accidental opening, and the ease with which they may be closed to retain any desired portion of the load. Hand-brakes are operated by means of a screw with pull-rods connected so as to transmit the pressure to each wheel of each bogie, and to permit of the coupling-up of air- or vacuum-cylinders as required. The defective action of ordinary side-buffers with screw couplings on sharp curves is mentioned, and the conditions for eliminating it are noted; central couplers are referred to; and the capacity of friction draft-gear is compared with that of the standard buffing and draw-gear of private-owners' wagons. The practice of weighing long wagons on short weighbridges is also alluded to.—**J. D. Twinberrow, A.M.Inst.C.E.,** *Proc. Inst. C.E., Feb. 1904.*

Construction of Iron and Steel Railway Wagons.

THIS paper deals in the first place with the advances made in the construction of railway wagons during the last thirty or forty years, detailing the successive steps from the wagon built entirely of timber, which was in vogue at the commencement of that period, down to the latest form of wagon made entirely of iron or steel, and the advantages accruing from this form of structure. The author compares the strength of timber and metal, and shows that for a 10-ton wagon built to the English standard regulations a steel frame can be made much lighter than a timber frame to carry the same load; while the strength of the timber frame is not to be compared with that of the steel frame. He goes on to describe the changes that have taken place in the form of construction of steel underframes and bodies. A great advantage of steel frames is the ease with which the various members can be replaced, owing to all drilling and machining being done either with steel bushed templates or by means of multiple drills and other modern metal-working machines, so that complete

interchangeability is ensured. Another point of great importance is the protection of iron and steel plates, channels, angles, etc., from rust and subsequent corrosion; and he points out that wherever practicable this should be accomplished by a coat of boiled oil, or of some suitable paint, as soon as possible after the metal has left the rolls. The omission of this precaution is frequently attended with disastrous results, as when once corrosion has been set up the metal is very soon destroyed, and in a short time it is useless for all practical purposes. The author lays particular stress on this point, as the very existence of the wagon depends upon it. On the other hand, when a metal wagon has been well taken care of and properly painted from time to time, it has been proved that the loss through corrosion is insignificant, and the wagon may be expected to last several times as long as one built of timber, for no amount of attention and painting will preserve timber for anything like the same length of time. The author points out that, although the cost of a metal wagon is at present somewhat higher than that of a timber wagon, the action of the Engineering Standards Committee in arranging certain approved sections will tend to reduce it greatly; and it may be expected that before long a wagon built of iron or steel will be produced at the same or even at a lower cost than one built of timber. With regard to the question of whether a large bogie-wagon or a four-wheeled wagon would be more economical for carrying goods on English railways, the author gives his opinion in favour of the smaller wagon, pointing out that loads in England are frequently too small, and the distance to be run too short, to allow of the use of a larger wagon; in fact, the average load which it is convenient to put in an English wagon averages under 5 tons. The paper also gives a short description of some of the couplings and buffers used in Great Britain and elsewhere. The paper is accompanied by twelve sunprints and eleven photographs, and by appendixes giving descriptions of various wagons, including bogie high-sided goods wagons for South Africa, coal-wagons, steel hopper-wagons for coal, rolled channel and pressed steel underframing, types of underframe trusses, etc.; and also a table giving a comparison of the ratio of load and tare for some of the principal wagons built under the author's supervision. This table shows that the tare of a wagon built entirely of steel is much lower per ton of load than that of a wagon built entirely of timber.—**A. L. Shackleford, A.M.Inst.C.E.,** *Proc. Inst. C.E., Feb. 1904.*

Iron and Steel Railway Wagons of High Capacity.

In this paper the wagon problem as affecting English railways is first considered, and a list is given of the companies which are using and experimenting with wagons of higher carrying capacity. The advantages of high-capacity wagons for coal traffic are shown by the saving their use will effect in the tare or non-paying load, and in the lengths of trains; and the difficulties in the way of their introduction, both at the collieries and at the points of discharge, are dealt with. The wagons described in the paper are designed for the conveyance of coal, and are suitable chiefly for traffic on the British railway systems. Several of the examples are of wagons already built and in traffic, which have proved in every way satisfactory, and have a lower tare than any other of the same class. They are all constructed of iron and steel, and are fitted with an either-side hand-screw brake, the self-discharging wagons having either-side door-operating and locking gear. The questions of the limit to the carrying capacity of bogie coal-wagons for traffic in this country, and the most convenient size, are fully discussed, taking into consideration the limited load-gauge, the sharp curves, and the fact that the wagons have to be provided with corner buffers. The difficulty of using screw-couplings for these wagons is dealt with, and some examples are cited of large coal-wagons of the bogie type in use in the Colonies, and a tabulated list is given of the bogie coal-wagons at present in traffic in Great Britain. Proceeding next to details of construction, the first example, and that with the lowest tare compared with the measurement load, is a 40-ton coal-wagon of the flat-bottomed type, arranged for discharging by hand-labour through openings in the sides. Although fitted with laminated bearing springs, this wagon is shown to be the lowest in tare of various constructions, and, at the same time, exceedingly strong. Details are given of the body, underframe, bogies, buffers, brakework, and other fittings; also of the test load to which the underframes and bogies have been subjected. Particulars are given of some 30-ton wagons constructed on similar lines to the 40-ton wagon, and comparisons are made with other constructions, both British and American. The construction of 20-ton four-wheeled flat-bottomed wagons and of covered goods-wagons, of both the four-wheeled and bogie types, is next referred to. The remainder of the paper is devoted to the construction and details of self-discharging wagons for the conveyance of minerals. The general advantages of this type of wagon, the points to be aimed at in design, so that the wagon may be as short as possible and self-clearing, and may fulfil the requirements of the various railways, are discussed, and for each example particulars are furnished of the length, tare, percentage of tare to measurement load, net capacity (expressed as a percentage of that of a flat-bottomed wagon of the same over-all dimensions), inclination of the various parts of the floor, type of bogie, and clearance to be allowed for it when traversing curves. The first example is a 40-ton wagon arranged so that the contents are discharged down a shoot between the rails, the mouth of the shoot being limited in length. A comparison is made between the work of receiving and discharging one of these wagons and wagons of the ordinary 10-ton type to carry the same amount of coal. Details of a test of two and a half times the maximum working load, which was carried out on one of these wagons, are given, and also the time taken to discharge 40 tons of coal. Other examples are given of a 40-ton wagon of similar construction to the foregoing, but arranged to dis-

charge its contents between the rails at three given points; an 80,000-lb. wagon for a 3-ft. 6-in. gauge railway, fitted with central buffers and arranged to discharge its contents outside the rails; a 100,000-lb. wagon, arranged to discharge part of its contents near the centre and part near the ends of the wagon; and a 20-ton four-wheeled wagon arranged to discharge its contents between the rails at the centre of the wagon, and having a 10-ft. wheel-base, and less tare than any 20-ton flat-bottomed wagon in use. Designs for 60-ton and 70-ton wagons arranged to discharge their contents between the rails are also outlined, showing the load it would be possible to carry with an increased load-gauge, such as that adopted in the United States and other countries. —**J. T. Jepson,** *Proc. Inst. C.E., Feb. 1904.*

MISCELLANEOUS.

Candle-power Tests of Welsbach Burners.

This article gives an abstract of that part of the Fourth Progress Report of the N.E.L.A. Committee (U.S.A.) for Investigating the Photometric Value of Arc Lamps which deals with tests of mantle gas-burners and of the naked gas flame. With a view of getting representative results on gas mantles of the Welsbach type, a variety of mantles were purchased in the open market. It was found that the candle-power of a gas mantle is dependent in a marked degree upon the gas pressure. So important is the relation of these two magnitudes that comparative measurements on mantles become meaningless unless conducted under conditions of constant pressure. The report contains numerous candle-power curves and other data, and concludes with a short series of tests of candle-power and gas consumption of the ordinary open gas flame. An assortment of tips was secured from different dealers conveniently at hand. In seeking to test these it was soon found that the nominal rating of the tip had scarcely any significance, either as regards the gas consumption or candle-power. A table and a diagram are given which summarise the tests on the open gas flame, and it is evident from these tests that the candle-power of gas as found in ordinary commercial service can be determined only by means of a very large number of tests.—*Report N.E.L.A. Com. Report Electrician, Vol. LII, No. 5,* pp. 166, 167.

Costs of various Heating Systems.

In this article the writer first describes various forms of heating systems, and the types of buildings to which the different systems are best suited. Considering the heating of buildings by systems, the writer finds that the costs run as follows, the values representing the cost per cub. ft. of contents heated: High-pressure live steam reduced, two-pipe system, with air-lines and no boilers, \$0·0129 to \$0·0176; low-pressure live steam, with gravity return and boilers, two-pipe system and air-lines, \$0·022 to \$0·024; exhaust steam, with back-pressure, \$0·0125 to \$0·017; exhaust steam, with vacuum returns, \$0·017 to \$0·02. Vacuum systems usually increase the heating cost from 10 to 15 cents per sq. ft. of radiation installed; ordinary hot-water heating, \$0·03 to \$0·035. For small buildings: Forced hot-water heating—factory work, \$0·013, a safer figure being \$0·90 per sq. ft. of radiation. In general the costs run as follows: Direct radiation, one-pipe gravity return with boiler, \$0·018 to \$0·022; two-pipe, as above, \$0·022 to \$0·024. Indirect radiation, gravity return, with boilers, \$0·03 to \$0·034. Direct indirect radiation, one-pipe gravity return with boilers, \$0·02 to \$0·025. Large houses cost about \$1·10 to \$1·25 per sq. ft. of radiation; city schools, direct radiation, \$1·60; city schools, fan system, \$2·60. Apartment hotels, about \$0·02 per cub. ft. of contents; club-houses, etc., with mechanical removal of vitiated air from a few of the principal rooms, figure approximately \$0·036; large hotels, and municipal buildings in general, heated by direct radiation, and having mechanical ventilation for the principal rooms, from \$0·04 to \$0·055. Large hospitals cost sometimes as much as \$0·07 per cub. ft. of contents. The average school building heated by the fan system alone costs from \$0·03 to \$0·033 per cub. ft.; with automatic temperature regulation this is increased to \$0·036 to \$0·04—in other words, the automatic control of the temperature costs about \$0·004 per cub. ft. of contents. The typical school-room measures 32 ft. by 28 ft. by 14 ft. high, containing about 13,000 cub. ft. Automatic temperature regulation for such a room costs approximately \$50.—**J. Byers Holbrook, M.E.,** *Eng. Rec., Vol. XLVIII, No. 26,* pp. 812–814.

Efficiency and Colour of Osmium Lamps.

At present Welsbach's new osmium lamps are not made for e.m.f.'s above 55 volts, or for less than 32 c.p., on account of the low resistance of the filaments. Five lamps of the above size, each containing three loops of wire 0·1 mm. in diameter, and totalling 40 cm. in length, were tested by the author, and gave the following mean results:—

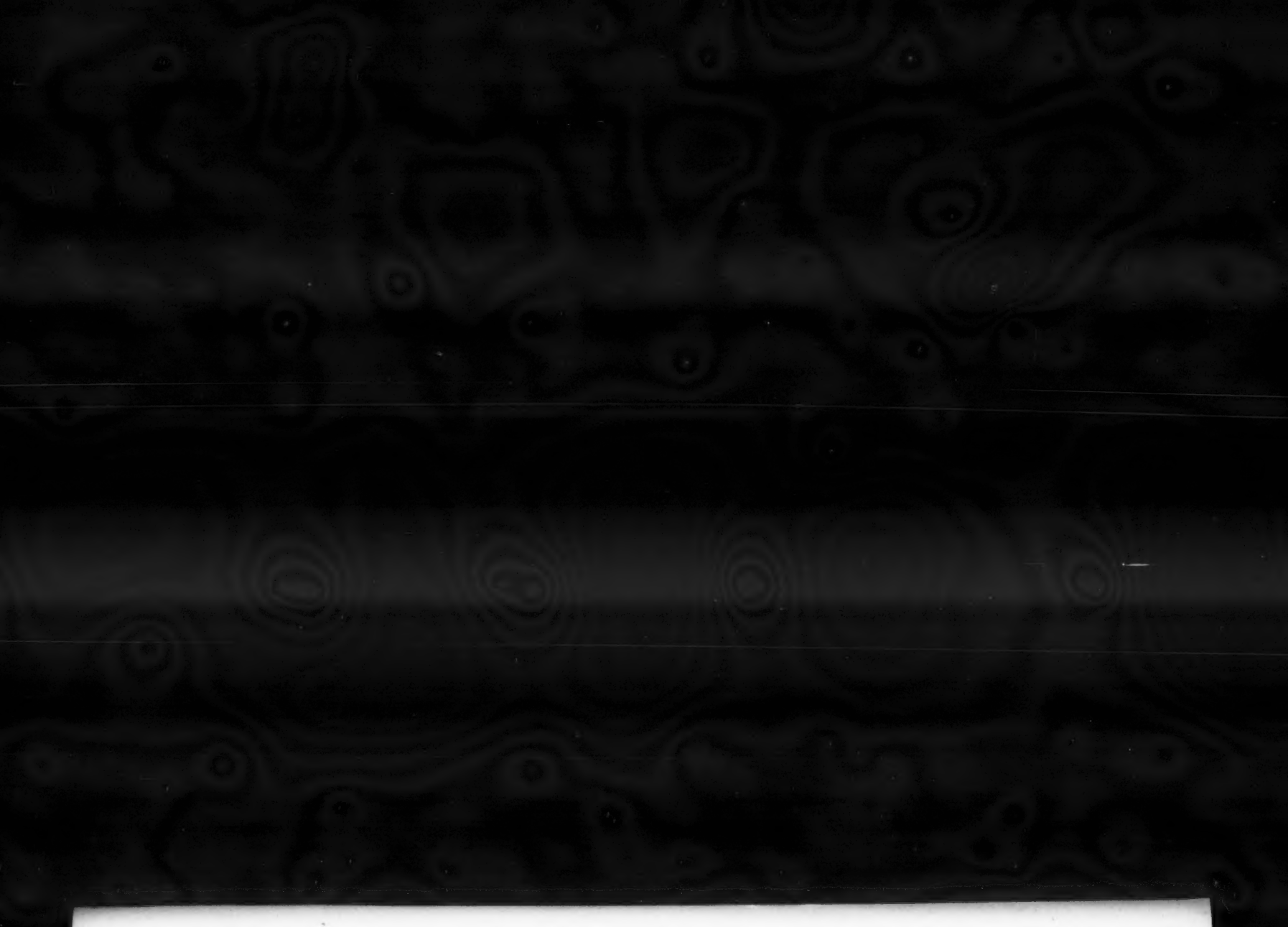
E.M.F.	Current.	Candle power.	Watts per candle.	Candles per watt.	Resistance in ohms.
30·3	0·744	2·3	9·8	0·102	40·7
35·4	0·812	4·81	6·0	0·167	43·7
40·1	0·90	8·76	4·26	0·235	45·0
45·5	0·97	14·5	3·04	0·330	46·8
50·5	1·032	22·0	2·37	0·422	48·8
55·6	1·106	32·6	1·89	0·529	50·2
60·6	1·178	45·4	1·57	0·637	51·4

The figures show that the increase of c.p. with e.m.f. is not so rapid in the osmium as in the carbon lamp, although the watts absorbed increase more rapidly. The important feature of the lamp is its high efficiency—just on 1·9 watts per c.p. (in a plane perpendicular to the axis of the lamp) at normal voltage. Tests made by Dr. Wedding upon eighteen lamps at an efficiency of 1·7 watts per c.p. gave an average life of 1,900 hours, some

of the lamps running for upwards of 4,000 hours. The average c.p. at the end of the life was 80 per cent. of its initial value, and the average efficiency 2·1 watts per c.p. The higher efficiency of the osmium lamp, as compared with the carbon lamp, is no doubt chiefly due to the metal being able to withstand a higher temperature; but it also appears to be a slightly more efficient light radiator, although this is probably reversed at the highest temperatures. The quality of its light is similar to that of a carbon lamp when run up to an efficiency of 2·1 watts per c.p.—**Prof. F. G. Baily,** *Electrician, Vol. XLII, No. 17,* pp. 646–647.—*E. J. W.*

Modifying Systems of Management.

REFERRING to the papers on shop management read at the Saratoga meeting of the American Society of Mechanical Engineers, the writer considers the opinions expressed by various members, stating that few have grasped the idea that what was advocated was not a series of isolated propositions, but a system of management having a number of parts working in harmony with each other—designed, first, to find out in detail what the maximum output of a plant should be, and then to make it to the interest of all concerned to obtain day after day that maximum output. The writer considers that when the employer has decided upon what he believes to be for his interest, his only successful method of procedure is to make it to the interest of the workman to do what is wanted. It must always be remembered that everybody is suspicious of new methods, and the only way to remove this suspicion is to show them that the new methods are going to help them in their work. The time-keeping department and the foremen usually find the system of daily returns from the men of such assistance to them that it soon has their support; and when the graphical daily balance shows weak spots, the best foremen realise they have at their command an instrument which will help them to increase the efficiency of their work by enabling them to put their efforts where they are most needed. Having stimulated an interest in making improvement, the adoption of detail methods is only a question of time. A schedule of what should be done in the office each day, and a graphical representation on that schedule of what was done, is essential to proper relations between the office and the shop. To be able to make quickly each day such comparisons as the following for the day before is quite as important as to make similar comparisons of the shop work: What drawings should have been completed; what drawings were completed? What purchase orders should have been placed; what purchase orders were placed? What material should have been received; what material was received? It costs but little to make readily available each day a knowledge of what has been spent in labour and material on any piece of work up to the close of the day previous.—**H. L. Gantt,** *Proc. Am. Soc. Mech. E., Report Amer. Machst., Vol. XXVI, No. 52,* p. 1794.

Maximum Illumination Output with Direct-Current Arc Lamps.

IN the case of the light from an arc-lamp having to be utilised in a determined direction only, the illuminating power may be increased in the required direction by imparting to the two carbons an abnormal position, placing them with their axes either in parallel directions at a certain distance or at a certain angle to one another. It is shown from the experiments of the author, that for each inclination of the axes there is a maximum candle-power corresponding to a certain displacement of the carbon, this maximum being, in the case of an inclination of 15, 20, 25, 30, 35, and 40 degs., superior by 141, 107, 69, 47, 26, and 14 per cent. respectively, to the amount of light given off from the carbons under the same angle in the case of their position being normal. From a comparison between the different maxima, it is shown that these will increase to some degree as they approach the perpendicular position of the carbon axes, and with the corresponding simultaneous increase in the displacement of the carbons. These experiments were carried out in the optical workshops of Carl Zeiss, Iena. — **Edwart Richter,** *Elektrotechn. Zeitsch., Vol. XXV, No. 5,* pp. 90–91.—*A. G.*